The Journal of ENGINEERING EDUCATION

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IMPROVEMENT OF THE ENGINEER– ARE WE WILLING TO PAY FOR IT?

C. C. FURNAS

Assistant Secretary of Defense for Research and Development
Chancellor of the University of Buffalo, on leave

Adapted from remarks at the Ninth Annual College-Industry Conference sponsored by the Relations With Industry Division of ASEE, Los Angeles, California, January 31, 1957.

At the request of the Secretary of Defense, Chancellor Furnas took a fifteen-month leave from the University of Buffalo to serve as Assistant Secretary of Defense from December 1, 1955 to February 15, 1957. In discharging that office, Dr. Furnas performed a staff function for the Secretary of Defense, advising on and guiding the research and development activities of all three military departments, Army, Navy, and Air Force. The duties also included, with the aid of a large civilian and military staff and national committees, consideration and approval of programs and departmental budgets for research and development.

Among those who are involved in any way with the pattern of science and technology of our nation, there is almost universal concurrence that we need both *more* and *better* engineers. This meeting is presumably concerned only with the "better" part of the picture, but if we are to consider the cost of improvement we can hardly exclude the "more" aspects altogether. We are already starting on an upswing in numbers of students, and unless we have the wherewithal to do the job properly, quality will inevitably suffer.

At the present time there is truly a shortage of engineers. There are several reasons for this, but the most important ones are involved with the military picture. In the background is the atomic bomb. This didn't immediately revolutionize warfare, but it did revolutionize attitudes toward the process of developing military weapons. The bomb demonstrated, for everyone to see, that the long-haired scientists and the engineers really did know what they were talking about. The military decided that a program of research and development in weapons was a continuing essential. Consequently, after the close of World War II, military research and development continued at an unprecedented high level. This caused an added demand for engineers that no one could have foreseen in 1940.

In the beginning of this movement, the extra demand was not sufficient to cause any critical personnel shortage. In 1947, when the Research and Development Board was set up in the Department of Defense, Dr. Vannevar Bush (who had been Head of the Office of Scientific Research and Development during the war) estimated that about $500,000,000 per year was all that could or should be spent on military research and development.

The program was begun at about that level. Then three important events came about. First, in 1949, the Russians developed their own atomic bomb, well ahead of the schedule we had rather naively set up for them. Second, the Korean War was started. Third, the development of

the thermonuclear or hydrogen bomb raised possible levels of explosive power by a thousand-fold.

All three of these events were frightening, and therefore were stimulating to the research and development program. In the current fiscal year the military research and development budget is over $1,600,000,000. This is about one-third of all the money spent on research and development work of the entire country, and the military programs employ about 40% of all the scientists and engineers engaged in such tasks. In addition, about $3,500,000,000 of procurement funds are being spent this year on the late development or "adaptation" phase. This covers the manufacture of such devices as prototype missiles, aircraft, and radar, their testing or evaluation, plus training for personnel and development of tactics. All of this must be done before a weapons system is ready for the arsenal, and these activities all require a large number of engineers. So the demand has now grown quite out of any bounds that had been visualized earlier.

Moreover, along with this increasing demand we now see three conditions of the past which are having a depressing effect on the current supply. First, was the low national birth rate of the 1930's. The result of this is obvious. Second, was the national policy toward higher education during World War II. Everyone was subject to the draft and graduate schools practically went out of business, so the normal crops of M.S.'s and Ph.D.'s who would now supply our teachers and advanced researchers simply were not ripened. This may have been the wisest national policy at the time, but we are paying dearly for it now.

Third, shortly after the war, several national societies and the government conducted surveys for the purpose of advising the rising college generations. Logically extrapolating from past experience, the surveyors concluded that the trends indicated there would shortly be an over-supply of engineers. It was therefore recommended that those who were not truly dedicated or were undecided should seek other fields. Probably for the first time in history the members of the younger generation listened to the advice of their elders. As a result, prospective students stayed away from engineering in droves.

In the face of the persistent demands, several trends are now under way which will soon greatly augment the numbers of graduating engineers and begin filling the vacancies. Hence, increases in numbers are inevitable. Thus, also, we face today the necessity for considering the cost of handling the larger numbers, as well as the cost of maintaining and improving quality of their education. When one thinks of cost, he first thinks of dollars. A greater amount of money will not automatically improve quality, but it will help, and certainly the problems will not be solvable without it.

One rather obvious way of improving engineers is to afford those who are qualified the opportunity for graduate education. Hence, I will present my thoughts on the needed increased dollar support for engineering study in general, but with a particular eye on graduate work.

Dollars Needed

Before we can arrive at an estimate of the dollars which are needed, however, it will be necessary to digest a

few data. During the past several years the ratios of number of engineering students enrolled at the beginning of their student period to the number of degrees granted in the appropriate year have been approximately as follows:

For undergraduates	6:1
For Masters	4:1
For Doctors	5:1

For the academic year 1955–56, the following numbers of engineering graduates have been reported:

Bachelors	26,306
Masters	4,724
Doctors	610

Everyone is entitled to his estimate of how many engineering graduates we should have per year in the near future, so I will suggest these as bogey figures: Bachelors 60,000; [1] Masters 10,000; Ph.D.s 2,000. If the past ratio of graduates to students-in-process holds, then the engineering student body should be of the following composition:

	Undergraduates	Masters Candidates	Doctors Candidates	Totals
Desired	360,000	40,000	10,000	410,000
Actual Fall '56 enrollment	251,000	22,500	3,400	276,900
Additional needed	109,000	17,500	6,600	133,100
Estimated cost per student per year	$3,000	$5,000	$6,000	
Added national cost/year	$327 millions	$87.5 millions	$39.6 millions	$454 millions

It is not possible to get exact costs of educating different segments of a student body, so I have made estimates of my own as follows for *engineering* students: Undergradates $3000 per year; Masters candidates $5000 per year; Doctors candidates $6000 per year. In these estimated costs, I am including the subsistence cost of the student himself (food, lodging, clothing which he, parents, or someone has to pay) at $1200 per college year.

The estimated total *additional* annual cost to handle the minimum appropriate task, then, is estimated at $454 millions, which must come from the pockets of students or their parents, from taxes, endowment income, or gifts. But this is merely holding the line; it is not a program which improves quality except to the extent that there are increased numbers of masters and doctors degrees.

To achieve improvement over the present, particularly for graduate students, we must improve our ability to attract and hold better men and women for teaching and research faculties. Salary isn't everything, but we have now arrived at the point where professorial salary increases are a necessity if we are not to slip backward. The average student-to-faculty ratio in engineering is about 12 to 1. A national student body of 410,000, therefore, requires about 34,000 instructors and professors. I suggest an average salary increase of $3000 per teacher per year as the minimum to provide the necessary retaining power. 34,000 times $3,000 is $102 millions additional demanded per

[1] Undergraduate engineering enrollment in the fall of '56 was 277,000, so we may expect about 46,000 bachelors in 1960.

year to achieve some increment of improvement in quality.

But this is not the whole picture. To improve quality in the future we must go further back than the college days, back toward the roots—at least into the high schools. In the high schools the proper and qualified persons are or are not motivated, and students begin to learn the basic principles of science and mathematics. There are 140,000 science and mathematics teachers in the nation's high schools. Many of these are but indifferently trained, many of them are teaching these subjects only part-time.

For the demands of the immediate future, I estimate we need an additional 100,000 scientifically-qualified, full-time science and mathematics teachers in the nation's high schools. Assuming and average salary of $8000 each, this calls for an additional annual expenditure of $800 millions.

From the above arguments we can now total the bill:

Added college and university costs for more students	$454 millions
Increases in faculty salaries	102 millions
Additional High School salaries	800 millions
	$1,356 millions
If you wish to deduct the subsistence cost of $1200 per capita, for 133,000 additional students, this figure can be reduced by	$160 millions
Then minimum total *additional annual* money needed from taxes, tuition, endowment, gifts, and so forth.	$1,196 millions

But even this is not all. Taking the country as a whole, many of our engineering buildings and much of our equipment are woefully inadequate in both quantity and quality. More students are inevitably coming and we can't teach engineering in tents. As a minimum, to improve what we have and to provide for that which must be new, I estimate that a capital investment of $3000 per student (present and prospective in the near future) is indicated.

For the suggested body of 410,000 engineering students, this calls for a capital investment of $1,230 millions. This might be considered a 20-year investment, but the money is needed now. The above estimates are admittedly rough, but I do claim that they are honest, and I believe they are minimum figures—there is no padding.

Even if the additional funds as outlined above were made available to the engineering education institutions and the high schools tomorrow morning, we would still be a long way from the answer to improvement. Until we find and retain additional good teachers, we'll be fortunate to hold our own in the quality department, in face of the increasing numbers which are inevitable. So when and if the dollars become available, we'll still have a major chore ahead of us. However, the dollars are an essential prerequisite to getting started.

My financial crystal ball is quite clouded at this point; but what I see there tells me that we're not going to get that amount of money for engineering. Moreover, education in the other essential professions, as well as for background liberal education, also needs substantial bolstering. We're going to be in serious difficulty in even holding the line on quality. But we must all dredge all channels as-

siduously for the additional funds that are necessary.

The direct tax route is the obvious path for those institutions which are supported by states or other governmental units; some federal assistance may also be forthcoming. A bill, H.R. 2450, was introduced in the House of Representatives, for instance, by Congressman Elmer J. Hubbard of Pennsylvania on January 10, 1957. It provides for substantial scholarship aid to a large number of undergraduate engineering students plus financial assistance to the institution, for increased engineering faculty salaries to place them in an equitable relation with industrial salaries, and for graduate work by students who planned to go back and teach science or mathematics in high schools. No one knows what the fate of this particular bill will be, but it does indicate the possibility of some aid from federal sources.

When emphasis is placed on the tax route, there is the ever-present danger of leaving the private institutions in an even worse situation than they face now. It will be a sad day for America if private colleges and universities should ever pass out of the picture, or sink below their present stature. I feel I am in a position to speak objectively on this point.

In my days beyond high school I have been closely involved, as student, faculty member, or administrator, with two state universities, three private ones, and one which was half state and half private. I can say without hesitation that each type of institution has its unique virtues, that they are complementary in character, that each is better because of the existence of the other, and that America would be greatly weakened if either private or public universities should cease to exist or be seriously weakened as a group.

Public and Private Education

When one contemplates the sweep of history, he observes something very interesting about the strength of the dual system of public plus private higher education. Although I cannot prove it in detail, I am sure it is approximately true that during the past two hundred years only those major nations which have maintained a system of strong private, as well as public, higher education have been able to resist the wiles and the will of a dictator, and have avoided being conquered or overrun by an enemy. I have the feeling that this is much more than a coincidence. There is a fundamental causal relationship here which can mean much to our future.

Hence, in our planning and implementation to obtain the wherewithal for supporting our future engineering education, I respectfully suggest that private and tax sources should receive about equal national attention. At this juncture it might also be well to point out that even state universities depend to a substantial and increasing degree on private sources of support. This support ranges from scholarships to money for buildings that are not part of the strict educational pattern, and on to foundation and industrial support of research. So we are all in the same boat, we vary only in degree.

Sources of Money

I have a suggestion to make which I am sure will at first strike you as naive. But let it vegetate in your own mind for a time and then see what it looks like. Suppose Congress were to

pass a simple piece of legislation which would, up to a certain small proportion, forgive 100% of the tax, if the amount were donated to accredited non-profit institutions working for public benefit (I refuse to call them charitable or eleemosynary institutions). The list would include colleges, universities, churches, certain research foundations, and health organizations. Such legislation would mean that the donations would be deducted from the tax bill, not from the income column. It would mean that the contributions would cost the donor nothing.

If there were legislation permitting such donations up to 5% of the federal tax, some 3 to 3½ billion dollars would be made available for these public institutions in the fiscal year of 1958. The distribution, if any, would be up to the taxpayer himself. There would be a scramble, competition if you choose, to persuade individuals and corporations to give to this institution rather than that one. But the character and pattern of the operation would all be within the framework and traditions of free enterprise. The important questions are: do we really believe in free enterprise? Are we really willing to pay for it?

I can think of several reasons why such a scheme is not practical, why it will not work. I recognize that there would be a small loss in tax income that would have to be made up by a slightly heavier levy. But the principal drawback would be something else. Legislative bodies have never been willing in the past, and will be very loth in the future, to make funds available for any purpose over which they do not maintain a substantial amount of control. Will the leopard change his spots? I don't know, but it might be interesting to give it the old college (or even political) try.

In the foregoing I have been dealing with costs that can be brought out in the open and scrutinized, even though the estimates cannot be exact. Another area calls for some dollar expenditure, plus a substantial amount of investment of human effort. I am speaking of industry-university collaboration to meet educational needs.

Advanced Cooperative Programs

In the highly desirable operation of upgrading engineers through graduate work, I feel that is very important for industries and government establishments to liberalize and enlarge their policies and programs for aid-to-advanced-education for employees. This is particularly important for the men who have received their first degree within the past five years. The pattern should not be confined to just paying part of the tuition for night classes. The willing and able should have appropriate time off, with full pay, to pursue graduate education at reasonable hours and with reasonable blocks of time. Even the small industries can pursue such a program with major, long-time benefits to themselves. If such a program is widely followed, I see some major enlargements and improvements in the cooperative type of engineering education at the graduate level.

For its own and the educational institutions' benefit, industry should make substantially more use than it now does of faculty talents for much specialized teaching in their plants. Conversely, industry should contribute the occasional or frequent services of competent engineers who have a flair for teaching, as an aid to univer-

sities in appropriate specialized instruction for their students.

Research Aid

Although industry in general has become research-minded, and though it does support some university research, the extent of such support is much too small. It can be substantially enlarged to everyone's benefit. A greatly increased number of research and design projects should be supported (including full overhead costs) for advanced students and faculty members in the engineering schools. This calls for time and patience on both sides and beneficial results won't appear next week, but in the long run everyone would gain.

The Time Needed

The next item of cost is that of time. We sometimes decry the time it takes to educate a man for a profession, and we search for ways to escape the calendar. We seek shortcuts and accelerated courses. But past experiments have been discouraging. Perhaps we can improve the education that is given in n years, but I don't think it is wise to try to reduce n. As a matter of fact it almost seems inevitable that n will increase.

Every young engineer should be brought to the realization that his education should never stop. If he is really capable and anxious to succeed, he should, on the average, count on spending at least six years of his life beyond the high school in formal education—although part of it may be intertwined with his professional practice and experience.

Effort and Interest

Finally, there is another investment even more intangible than time—the investment of human effort and individual interest. If we are really to improve, industrial as well as educational leaders must invest more time and effort in collaboration on problems which are common to the whole pattern of our industrial society. In my opinion our colleges and universities can also advance their public relations to arouse the necessary sense of responsibility and level of interest on the part of industry, government, and the public.

I have presented these thoughts to fit in the frame with the more or less standard and accepted educational pattern which has been with us for a long time. But age is not necessarily a guarantee of quality—we should always be free to examine and re-examine it. Perhaps our basic pattern of engineering education can be improved—we should experiment judiciously—but I'm sure that substantial, added increments of dollars, time, collaboration, effort, and individual interest are required, whatever the details of our educational process may be in the future.

Annual Meeting — Cornell University

Ithaca, New York June 17-21, 1957

DO YOU KNOW . . . .

► . . . . That if you are going to the Annual Meeting at Cornell from June 17 to 21 and haven't filled out the pre-registration, housing, and special events cards, you should do so at once? They came with the preliminary program. Having the cards returned early materially aids in the planning and prediction the local committee needs to make. Your prompt action will be appreciated! The Intercollegiate Rowing Regatta will be held at nearby Syracuse on Saturday, June 22, in case you are interested.

► . . . . That travel information on how to get to Ithaca for the Annual Meeting was in the April "DYK"? It is repeated here for your convenience.

Air . . . . . Mohawk Air Lines
Railroad . . . . . Lehigh Valley from New York, Philadelphia, and Buffalo
Bus . . . . . Greyhound
Car . . . . New York State Thruway. Use Exit 41 near Waterloo; Ithaca is 48 miles south on Route 96.

Make your plans now—pre-registration, housing, and special events cards came with the preliminary program!

► . . . . That the presidents of institutions having colleges of engineering are being specially invited to attend the Annual Meeting on Tuesday and Wednesday? This is a "package invitation" extended by ECRC and ECAC to be present for certain highlights—the Annual address of President W. L. Everitt, the progress report of the Committee for Development of Engineering Faculties, the ECRC conference for presidents and institutional representatives, the ECAC-ECRC annual dinner at which President E. A. Walker of Penn State will speak, ECRC's General Session on Wednesday morning devoted to the encouragement of research and graduate programs through the efficient use of educational manpower and facilities, and ECAC's Military Affairs Committee's Tuesday afternoon conference.

► . . . . That Engineers Joint Council's report "Professional Income of Engineers—1956" is now available? Copies may be purchased from EJC (29 W. 39th St., New York 18, New York) for $1.50 each. The survey covers 107,000 engineering graduates in industry, government, and education. 5,674 engineering faculty members from 116 institutions are included. That number is estimated to be slightly over one-half the total engineering education staffs in the United States. In a series of graphs, salaries are related to the year of graduation. Annual earnings for all engineers in about eighteen industrial classifications, and for engineers in engineering education are presented. For "engineering education" both "basic teaching annual salary" and "total annual income from the practice of engineering" are considered. M. M. Boring, past president of the Society, was chairman of the committee making the study.

► . . . . That EJC's "1956 Assembly Proceedings" are available from 29 W. 39th St., N. Y., for $1.00 per copy? A few highlights of some of the papers presented are: engineer's salaries have not kept pace with rising national economy, productivity,

and labor wages; merit rating and position evaluation advanced as means of salary administration; government taking a new look at employed engineers salary-wise; overseas opportunities are vast.

► . . . . That ECPD has distributed about 35,000 copies of "After High School—What?" to the principals and superintendants of schools throughout the country? A second mailing to guidance personnel is being made this month, and along with it will be a list of accredited engineering curricula. EJC has appropriated $4,800 to ECPD for this second mailing.

► . . . . That a limited number of copies of the brochure on the National Survey of Technical Institute Education can be obtained from the office of the ASEE Secretary? It discusses the purpose, background, and need of the survey, defines engineering technician and technical institute education, and outlines the procedure being followed.

► . . . . That the Relations With Industry Division has prepared an eleven-page mimeographed booklet which can be called a Manual for the Formation of Local RWI Sections? It was prepared as a guide for those groups interested in fostering effective and constructive liaison between educators and representatives of industry—those who utilize the product of the educators. Anyone interested can request a copy from Ralph A. Emerson, Industrial Relations Supervisor, E. I. du Pont de Nemours & Co., Wilmington, Delaware.

► . . . . That registration for the summer surveying school—the Fourth National Surveying Conference—at Naches, Washington, should be submitted before 1 June? The dates are August 4 to August 10. Facilities are available for 100 people, and registrations will be accepted on a first come, first served basis. Information can be obtained from C. L. Barker of the State College of Washington, Pullman, Washington.

► . . . . That May always brings one sad duty? About 200 letters need to be prepared and sent to members delinquent in dues for two years, saying that if payment is not made by 1 July they will be dropped from membership. There are about 350 who have not yet paid this year's dues; if you are one of them won't you please pay now? If you don't, there will be no JOURNAL for you next year.

► . . . . That the recently published list of *Emeriti for Employment* gives the names and addresses of 24 retired engineering college professors who are in good health and who desire to continue working in some capacity? Civil, electrical, mechanical, engineering economy, aeronautical, chemical engineering, and drawing are the areas covered. If you need staff, or if you wish to list your name, write to The Emeriti Census, Box 24451, Los Angeles 24, California.

W. LEIGHTON COLLINS
Secretary

MEET YOUR ASEE OFFICERS, 1956-1957

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(For biographical sketch, see JOURNAL, September 1956.)

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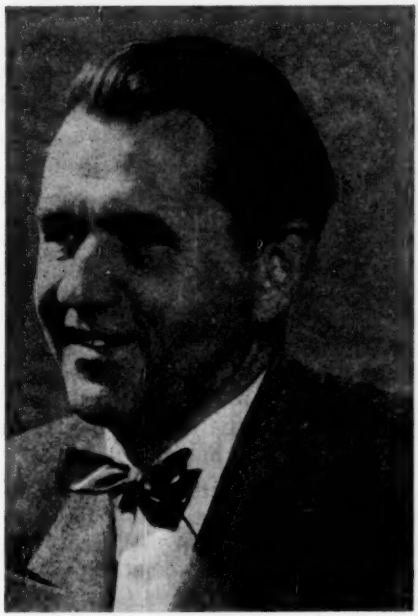
Editor of the Journal:

E. C. MCCLINTOCK, JR., University of Illinois, Urbana. (JOURNAL, October 1955)

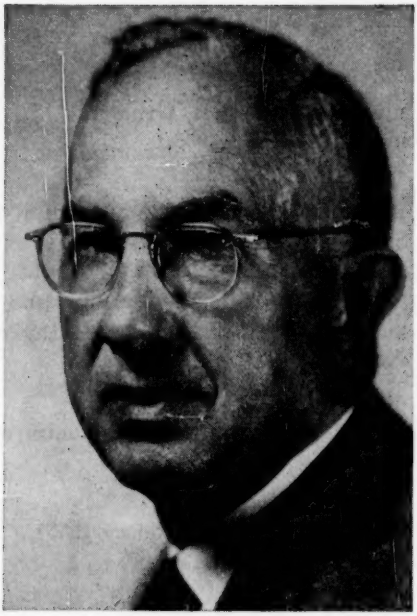
FREDERICK C. LINDVALL, Vice President in Charge of General and Regional Activities, has been a member of ASEE since 1941. A 1924 graduate of the University of Illinois, he received his Ph.D. from the California Institute of Technology, and practiced engineering with the General Electric Company until 1930.

Since 1945 Chairman of the Division of Civil, Electrical, Mechanical Engineering and Aeronautics at C.I.T., he also taught at Pasadena from 1930 to 1942. During the war he supervised the OSRD section on rockets, underwater ordnance, welding tests, and aspects of the Manhattan project; he won the Naval Ordnance Award and the Presidential Citation for Merit.

His consulting and research activities range broadly, in vacuum switching, oscillography, high-voltage and glow discharge phenomena, vibration and dynamics. He holds numerous professional society memberships, and serves on eight boards of directors.



F. C. LINDVALL



C. A. BROWN

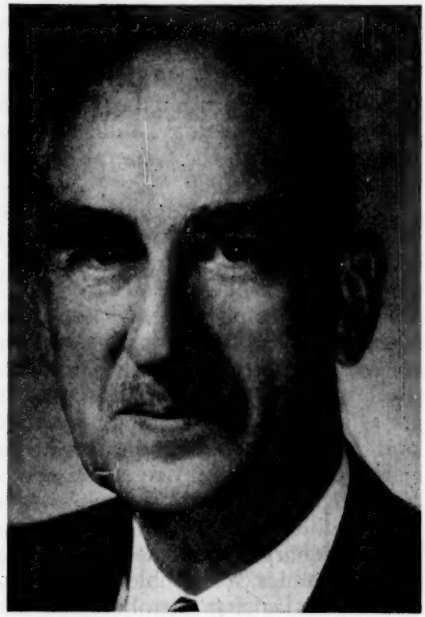
In Charge of Instructional Division Activities, Vice President C. A. "BERT" BROWN is Administrative Assistant to the President at General Motors Institute, Flint, for Instructional and Faculty Development. Prepared for a teaching career with the B.S. degree at Purdue University and the A.M. at the University of Chicago in 1929, he came to the Institute as Chairman of the English Department after five years of teaching at Purdue.

Member of the ASEE since 1931, he has been Chairman of the English Division, Representative on Council, both Divisional and Michigan Section, and has just concluded a thoroughgoing revision of the Constitution and By-Laws as Chairman of that Committee. He also belongs to NCTE, CEA, ABWA, and the NEA; a major civic interest has been the Flint Institute of Arts.

Vice President for ECAC, WILLIAM T. ALEXANDER holds two degrees from Northeastern University, B.M.E. 1926 and B.S. 1931, with a M.A. in 1935 from Boston University, where he also studied physics and administration.

By choice a teacher, his career began at Northeastern in 1926; since 1945 he has been Dean of Engineering there. He saw active war duty with the Navy as an officer on transports and at Todd Pacific Shipyards, returning with the rank of Commander, advanced to Captain in 1950. He is Educational Advisor for the Naval Reserve Officers School in Boston.

Beyond instruction, he has held positions in industry and has been active as a consultant. Affiliated with many professional societies, notably ASME, for which he is Chairman of the Boston Section, he first joined ASEE in 1929.



W. T. ALEXANDER

RAYMOND J. WOODROW, Vice President from ECRC, was graduated with the B.A., from Williams College, and a B.S. and M.S. from M.I.T. in 1937. His industrial experience included two years with General Electric, and Philadelphia Electric Company until 1941.

He was then in charge of technical liaison with foreign countries for the OSRD, and was Deputy Chief of the Transition Office, speeding research to production. From 1944 to 1946, he supervised the Cadillac large-radar project at M.I.T. Radiation Laboratories, receiving the Certificate of Merit from the Government and of Commendation from the Navy.

He is now Executive Officer and Secretary for the Committee on Research and Inventions, Princeton University, as well as a widely-known consultant. In ASEE since 1952, he heads ECRC and our relations with the Federal Government.

JOHN GAMMELL, Treasurer, received his B.S. degree from the University of Washington, Seattle, in 1928. He soon joined the Allis-Chalmers Manufacturing Company, where he currently is Director of Graduate Training.

Mr. Gammell has been associated steadily with Allis-Chalmers, as graduate student, sales representative, and Supervisor of Sales Training. Throughout, he has also been interested in organizations and committees associated with professional education and development.

For three years during World War II, he served in Washington as Chief of the Electrical Equipment Branch for the War Production Board. He has been a member of ASEE since 1949, is a registered professional engineer, and is active in other societies, including AIEE, ASME, and NSPE.

JOHN GAMMELL

PROPOSALS TO MEET THE STAFF CRISIS IN ENGINEERING COLLEGES

JOSEPH F. ZIMMERMAN

Assistant Professor of Economics and Government
Worcester Polytechnic Institute
Worcester, Massachusetts

Immediate proposals in the general area which is being attacked in a long-range way by the ASEE Committee on Development of Engineering Faculties, headed by Dean Hazen.

Within the next four years, colleges will face a tidal wave of students. Enrollment is expected to double within the next twelve to fourteen years. Much has been written recently about the need for greatly increased staffs to accommodate the forthcoming flood of students, yet relatively few specific proposals have been made for immediate augmentation of faculty ranks. Five such proposals, designed to avert a staff crisis, are presented in this article. These represent ways in which college staff members can help their cause at once, supplementing and assisting the long-range efforts of the ASEE Committee headed by Dean Hazen.

The future shortage of staff members will undoubtedly be greatest in engineering and the physical sciences. Many engineering colleges are experiencing these staff shortages already. Today's are only a preview, however, of what the problems will be by 1970 unless a remedial program is initiated soon. The suggestions below are designed to begin discussion of such a program.

Recruiting Campaign

An energetic recruiting effort must be started and continued if engineering colleges are to meet staff needs in time. College students must be sold on college teaching as a career. Individual professors as well as college administrators must become recruiters in self defense. The sales program must be directed to all students, freshmen as well as upperclassmen, and to graduate students. It is never too early to urge that students consider seriously their future careers. An active recruiting program not only may insure an adequate supply of staff members, but also will have a healthy effect by engendering a more mature attitude in students who decide upon college teaching as a career. These students will recognize the need for serious study if their goal is to be realized.

That college teaching is rewarding is a truism to most members of the profession, but not to most students. Students often experience difficulty in comprehending why an outstanding professor is teaching at their college rather than working in industry at a substantially larger salary. This question is heard frequently on most campuses. The advantages of a college teaching career are many and should be brought to the attention of all students. Some of these advantages will be considered next in general terms, but not exhaustively, and

with no attempt at any order of importance.

Rewards of Teaching

Salary. Salary is discussed first because engineering students generally believe that they will "starve" if they enter the college teaching profession, whereas they will be able to live "royally" if they accept a position in industry. This statement may be an exaggeration, but students generally are laboring under misconceptions about the incomes of engineering professors. Student ideas of college salary scales stem in part from talk about liberal arts colleges, which often pay less than public school systems. The salary scale of engineering colleges generally is much higher.

Students should also be informed that a young instructor's salary, supplemented by summer employment and consulting and research work during the school year, may well equal or exceed the salary that a young engineer receives his first few years in industry. In addition, the future is bright for further salary increases because of the rising number and size of gifts that colleges are receiving from industry and foundations. If students can be assured that they will make at least as much money during the first few years of their teaching career as they would in industry, a greater number of students will be induced to enter the teaching profession. After four or five years teaching experience, a young man may decide to remain in the profession even though to do so will mean a financial sacrifice. The non-material advantages of the profession by then may outweigh monetary considerations.

Contribution to the Development of Young People. Working with students is perhaps the chief non-material reward of teaching; knowing that one has contributed intellectual growth is richly satisfying.

Prestige. Surveys reveal that medical doctors and college professors are ranked by the general public as the professional people with the most prestige. It is true that one cannot live solely on prestige, but "egos" need to be nourished as well as bodies. Furthermore, the high standing of college teaching opens many doors in the community and in society.

Research. Opportunities to engage in research are plentiful at most engineering colleges. Professors have greater freedom to engage in basic research and to select projects than do engineers and scientists in industry. Laboratory facilities, materials, and assistants are available to college professors without personal cost. Additionally, research is, of course, financially rewarding and supplements a professor's salary.

Consulting. College professors are in great demand as consultants. Consulting work is another source both of supplementary income and of valuable, rewarding experience. The contacts made and the experience gained greatly assist the professional development of the teacher.

Publication. A college teaching career affords the facilities and opportunities to write and publish. Royalties from textbooks are a major source of supplemental income, and journal publication a valuable means to professional recognition and prestige.

Library Facilities. College professors have immediate access to fine libraries. Such facilities are of the utmost importance to individuals who are interested in education, research,

and publication. An excellent library is also essential if one is to be well informed on latest developments in his field.

Stimulating Intellectual Surroundings. To be creative, a mind must be active, and intellectual activity is difficult in isolation. The presence of associates with new thoughts and ideas creates a climate of creativity. The exchange of views is highly stimulating and furthers the development of one's own ideas.

Freedom. A college teaching position generally allows considerably more freedom than an industrial position. A professor usually is limited only by the necessity of meeting classes and attending departmental, faculty, and committee meetings.

Naturally he must be available to his students, but the hours can be arranged for mutual convenience. There are very few other positions which allow an individual as much mental and physical freedom during the "working day." A professor also has a substantial portion of the year free—three months during the summer, vacations, and holidays. This usable time allows the professor to travel, engage in research, work in industry, write, or just to relax.

Geographical Location. Many individuals consider geographical location to be one of the most important factors in selecting a position. The presence of colleges throughout the United States and the world affords a teacher wide choice of geographical locations, and exchange professorships afford professors an opportunity to travel. Positions in industry, by contrast, often are located geographically according to specialties. An individual may prefer to live in a certain area, but no industrial positions may be available in the area in his field.

Living Conditions. College communities offer much in the way of livability. College campuses usually are aesthetically attractive and many colleges are located in clean residential towns, ideal places in which to raise children.

Community Activities. The college teaching profession affords many opportunities to those who enjoy participating in community activities. Invitations to participate in community activities flow freely to professors.

Value of Service. In these troubled times, engineering professors perform a vital service to the nation. Great concern is expressed that the Soviet Union is producing more engineers and scientists than the United States. Engineering and science professors contribute to the nation's welfare not only by turning out the quantity of engineers and scientists needed, but also men with training of the highest quality. Service to the community and mankind also should be noted. Engineering colleges graduate young men who will provide leadership for the community and the nation.

Latest Developments. The time and facilities available to college professors generally enable them to keep up with the latest developments in their special fields. Graduate study and advanced degrees are open to instructors. Similar opportunities outside the college teaching profession are limited.

Junior Chairs

The differential between college and industrial salary scales for young men widens rapidly four or five years

after graduation. It is at this point that many young instructors, because of financial pressures, decide to leave the profession and to accept positions in industry. To reduce the salary differential, it is proposed that junior chairs, endowed by industry, be established for instructors and assistant professors. Colleges are charitable institutions. Industry is indebted to the colleges for furnishing engineers and scientists. Increasing contributions from industry recognize a responsibility to support colleges.

Junior chairs would help to attract competent young men to the profession. Because the salary scales at many colleges compare favorably with industrial salary scales during the first few years that a young man is in the profession, it might be advisable to require four to five years teaching experience as a prerequisite for eligibility to hold a chair. The added income of $1,000–$1,500 would be sufficient to induce many young staff members to remain in the profession at a time when they otherwise would seriously consider leaving.

Work-Teach Program

Engineering colleges should consider the feasibility of cooperating with industry in the development of a "work-teach program." Under this program a professor would teach one semester or one year and work in industry the next semester or the next year. A "work-teach program" would greatly supplement a professor's income and provide valuable practical experience which would enhance the effectiveness of his teaching. Such a program involves scheduling difficulties, but these should not prove insurmountable.

Part-Time Instructors

Unless more young men can be persuaded to enter the college teaching profession, the forthcoming flood of students can be accommodated only by the use of a greater number of part-time instructors. A re-examination of the role that part-time instructors can fulfill in the field of engineering education must be undertaken.

Symposia

The American Society for Engineering Education should consider the feasibility of sponsoring symposia on the critical subject of the staff crisis. Symposia would publicize the need for staff members and would also be productive of constructive proposals to solve the staff crisis.

Conclusions

The time has arrived when engineering colleges must initiate a strong recruiting program to attract young men to the college teaching profession. Unless the staff problem is solved, many qualified and deserving young men will be deprived of the opportunity to obtain an engineering education.

A high-pressure sales program is not proposed. Rather, the advantages of the college teaching profession should be brought to the attention of students. Knowledge of the many rewards of a college teaching career should be sufficient to attract young men to the profession.

Misconceptions concerning salaries at engineering colleges should be corrected, and the relatively bright out-

(*Continued on page 738*)

APTITUDE TESTS FOR ENGINEERS

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Presented at the Northern Regional meeting of the Pacific Southwest Section of ASEE, May 5, 1956. Recommended for publication by the Section. Dr. Harder bases his views on experience in the Student Counseling Center of the University of California at Los Angeles.

Standardized tests are generally given for one of two purposes: To describe the group taking the test, and to predict how well an individual is likely to do in some specified activity on the basis of his test score. Here we will be concerned mainly with analysis and prediction.

Aptitude versus Ability

Before we begin discussing tests, perhaps we should agree on a definition of an aptitude. Without going into the controversial relative contributions of heredity and environment, we can safely say that an aptitude is a latent, or potential capacity "to acquire with training some (usually specified) knowledge, skill, or set of responses, such as the ability to speak a language or to produce music." In referring to a person's aptitude for mathematics, art, law, or carpentry, we are looking to the future. His aptitude is, however, a present condition, a pattern of traits possibly indicative of his potentialities.

Ability, on the other hand, means "power to perform responsive acts." The skill has been developed, the learning accomplished. We can infer from this that the aptitude for this skill had previously been present. The term aptitude has, therefore, a forward reference, a predictive quality. An ability refers to the *status quo,* and is primarily descriptive. In another sense we use the term ability as though it were synonymous with aptitude, i.e., we tend to judge capacity for additional learning in the same area in relation to the quality and quantity of the present level. For example, we generally judge a student's fitness for a second course in calculus on his performance in the first—a forward reference.

Grounds for Prediction

In predicting from a test, three conditions must exist—a criterion, which is the final goal we wish to attain, a measuring device, and a known relationship between the two. Defects in, or unreliability of either the criterion or the measuring device seriously affect or limit the relationship between the two. This relationship we speak of as the *validity* or *predictive capacity* of the instrument.

Without going into the reasoning involved, it has been said that the predictive capacity of any test or set of tests can rarely exceed 0.70 (a correlational coefficient, not a percentage; 0.00 equals zero utility, success barely equal to pure chance, 1.00 perfection) because of the unreliability of the criterion. If it is noted that criteria of success always boil down to human judgment—in the assignment of grades, in ratings of success,

and so on—and if we have experienced difficulty in getting raters to agree, I think we can accept this estimate as fairly accurate.

To discuss aptitude tests for engineers, we should next agree on the aptitudes, and perhaps other characteristics, necessary for success as an engineer. As a convenient guide I should like to use the pattern of skills listed as being necessary for engineers in the Minnesota Occupational Rating Scales, revised edition. These scales reflect the judgment of a group of competent and experienced vocational and industrial psychologists as to the amount of certain aptitudes and abilities required for success in 432 occupations.

Ability areas rated are as follows: academic, mechanical, social, clerical, artistic, musical, and physical. Ratings consist of letter grades which represent the amount of the ability required for success (A, 91–99 + %; B, 76–90; C, 26–75; D, 1–25). Requirements are revised upward for artistic and musical areas. Ratings for three engineering groups are as follows:

PER CENT OF ABILITY REQUIRED FOR SUCCESS

	Academic	Mechanical	Social	Clerical	Artistic	Musical	Physical
Architectural	A (91–99%)	A (91–99%)	B (76–90%)	B (76–90%)	A (97–99%)	D (1–25%)	C
Civil	A	A	C (26–75%)	B	C (26–90%)	D	C (26–75%)
Mechanical	A	A	D (1–25%)	B	D (1–25%)	D	C

It can easily be seen that engineers in general require the highest degree of ability in the academic and mechanical abilities. Either by intent or coincidence, too, our measuring instruments seem to be concentrated in these two areas, and, with the possible exception of clerical ability, these skills are the easiest to measure.

Tests of academic aptitude are those which assist us in predicting how well a student is likely to do in a formal academic training program. Tests of intelligence or of mental ability fall into this general category. I shall not attempt to review the voluminous literature dealing with the prediction of academic success, or even the ample number of studies dealing with engineering success. For this type of information I refer you to the *Fourth Mental Measurements Yearbook* by Buros, or a volume by Donald Super entitled *Appraising Vocational Fitness.* I will try to acquaint you with the general results only, and will speak only of a few well-known tests which have been applied to the prediction of success in engineering training.

Specific Tests

1) Many of you are no doubt acquainted with the ACE, the American Council on Education Psychological Examination. It is the most commonly used test for entering college students. In addition to a total score, the instrument yields scores for both quantitative (Q) and linguistic (L) aptitudes. A number of studies have been devoted to the relationship of test scores, both total and part, to some criterion of success in engineering training. The results have been disappointing to those who expected a quick, easy, and accurate way to discharge their responsibilties in the selection of training candidates. Correlational coefficients, or predictive

indices, have ranged from 0.06 to around 0.46, with a median of about 0.32. But the most unexpected result has been the discovery that the L score is as satisfactory for predicting success in mathematics and science as is the Q score.

2) The Tests of Primary Mental Abilities were constructed after a careful and thorough-going analysis by factorial methods of some sixty separate testing instruments, and each mental factor, or ability, represents a relatively unique type of mental functioning. Comparing scores from this test with grades of engineering freshmen yielded *r's* (single correlations) of 0.04 to 0.36. Multiple correlation (R) for five factors was 0.51. Findings from these studies support our conclusion drawn earlier from work on the ACE part scores to the effect that verbal and general intelligence tests are at least as effective predictors of success in technical courses as are the more quantitative tests.

From the foregoing it must be clear that we can't expect to make accurate estimates of level of academic ability from this type of test alone. But if we also use subject-matter grades, scores on reading and achievement tests, performance in the environment, and some estimate of perseverance in academic and related tasks, we have enough material on which to base a rating with some confidence.

Mechanical Ability Difficult

When we turn to a discussion of mechanical ability, however, we lose whatever comfort there is in looking at an aptitude as a separate, relatively unique, characteristic. We are, in addition, still handicapped by the traditional relegation of mechanical work to the lower rungs of the occupational ladder. Because initial research in this area was restricted to the lower level occupations, the label "mechanical ability" acquired the stigma of being somehow of less value to man and to society than other abilities, especially the academic.

Teachers, and counselors too, often falsely assume that any student who is "too dumb" to perform at a high level in the traditional academic courses will, by that very token, be successful in printing and woodworking shops. In part at least, this accounts for the vast number of studies reported which deal with success in technical courses. It can easily be shown that certain high level professional people such as engineers, architects, surgeons, and physicists also deal with matters involving neuromuscular coordination, manipulative skills, space relationships, motion sense, and timing.

Perhaps I should confess right at the start that if mechanical ability tests exceed tests of academic ability in their predictive capacity, it is by a very small amount. The Minnesota Mechanical Assembly Test, The MacQuarrie Test of Mechanical Ability, The Minnesota Spatial Relations Test, The Minnesota Paper Form Board Test, and the Bennett Mechanical Comprehension Test are among the most frequently used mechanical tests. Correlations between test score and grades in engineering courses at the freshman level range from 0.06 to 0.42, with *r's* somewhat smaller using grades at completion of training.

These rather small coefficients, while statistically significant, seem rather discouraging when we think of using them in predicting success in training. However, if we use certain

combinations of test scores in a multiple correlation (R) the picture is somewhat improved. In my own unpulished study of the prediction of engineering success, an R of .61 was obtained, the variables used being the ACE, a locally constructed mathematics test for entering college students, a paper and pencil test of three-dimensional spatial relationships, and the Minnesota Paper Form Board Test. The inclusion of the Bennett Mechanical Comprehension Test did not significantly increase R. Other studies using different variables and in different combinations show R's of 0.46, 0.45, 0.59, 0.61, and 0.66. (Note that these values closely approach our hypothetical limit.)

Custom-built batteries do not seem to produce better predictive indices. Some of the larger universities of this state have constructed qualifying examinations for freshmen and juniors. At these schools a student must pass two hurdles before he is admitted to the School of Engineering. He must first qualify for admission to the university, and he must score above a minimum level on the appropriate examination. In spite of this rigorous selection, from one-quarter to one-third of the entering freshmen do not complete the first year of training and many more do not complete the four-year period. Why?

It seems to me we are barking up the tree after the cat has fled. We know that academic and mechanical abilities of a high order are required for successful completion of training, so we continue to experiment to improve our selection. Many individuals have begun to be aware that perhaps there are other characteristics which are required for successful training, but few have embarked on a research program to ascertain what these might be and whether or not they can be measured.

It seems to me, in fact, that some aspects of personality, such as interests and values, might play an important part in the selection of engineering candidates. In counseling we have often felt that these aspects of personality were important to the person making a curricular or vocational choice. I feel certain that a formal research project would reveal equal values for admitting institutions. Let me relate an example.

On one of the campuses of this university, I was engaged in counseling students. The engineering department on that campus made it a policy to place a student on subject to dismissal status if at any time he failed to maintain a C average. He could not re-enroll without permission of the Dean, and he couldn't even see the Dean until he had gone through a counseling appraisal. We saw a lot of engineering students. One of the things we noticed was a particular pattern of scores on the Strong Vocational Interest Blank for most students for whom there seemed reason to believe that they wouldn't complete training. Even though no formal study was made, the occurrence of the pattern was too frequent to be solely coincidence.

Research on the Strong has not been lacking, but the concern has been not with patterns, but with correlating grades and scores on the engineering scale, the general result being r's of around .25 to .32. Similarly, on the Kuder Preference Record, engineers score high on the scientific, mechanical, and computational scales, but so do students in other majors.

Another approach which may have

value is the use of the Minnesota Multiphasic Personality Inventory in the classification of students of different majors. With groups of engineering, business, and education seniors who were about to graduate, use of this test (ignoring the established scales and making item differentiations) gave correct classifications for 80% of the engineers, 80% of the education majors, and 67% of the business students. A cross-validation study using another group of education students showed a decrease in percentage of correct classifications, but there remained a two-out-of-three chance for correct classification—an improvement of 50% above chance. With some refinements, this technique seems promising.

With all of the public clamor and publicity relating to our country's need for scientifically trained personnel, it isn't beyond expectation to find our presently crowded facilities for scientific training even more in demand. With an increased demand there will be an increased need for wise selection in order to utilize our facilities to the best advantage.

Advice

To those of you who may be responsible for advising or counseling students relative to their entry into engineering training, let me repeat what I have heard many teachers of engineering state: An interest and skill in mechanics is *not* synonymous with engineering interest and skill. Make certain the student has a high degree of academic and mechanical ability, but also ascertain whether he can read and write with some skill. In spite of a segment of public opinion, engineers are *not* uncommunicative and inarticulate, and a student who is, is not likely to succeed in engineering training.

PROPOSALS ON THE STAFF CRISIS (*Continued from page 733*)

look for salary increases should be emphasized. The establishment of endowed junior chairs sponsored by industry and "work-teach programs" should help to alleviate the salary situation.

The role of part-time instructors should be re-evaluated. Increased use of part-time instructors will aid in the solution of the staff problem and also will provide such men with work experience as well as with academic experience.

The time for planning and action is now. Enginering colleges cannot afford to wait much longer before facing up to the staff problem if a future crisis is to be avoided. Every college administrator and professor can assist in the solution of the staff problem by acting as salesmen for the college teaching profession.

MODIFICATIONS IN FRESHMAN MATHEMATICS FOR ENGINEERS

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A paper presented at the Annual Meeting of the National Council of Teachers of Mathematics, Milwaukee, Wisconsin, April 12, 1956.

Professor Zant is Director for 1956–1958 of one of the Academic Year Institutes sponsored by the National Science Foundation for high school science and mathematics teachers. These Institutes involve nine months of training in science and mathematics on the graduate level for groups of fifty highly selected, experienced high school teachers.

The term "Mathematics for Engineers" has little meaning by itself. It is necessary to know what kind of engineering, what level of engineering study, what level of engineering practice, and the like, are under discussion. We shall discuss here the minimum in mathematics for the study of engineering, something about the maximum, and the kinds of modification proposed and made, with their implications.

It is plain to those working in the field of engineering education that the engineering student should study mathematics beyond the calculus. This should be partly for the purpose of securing an adequate mastery of the calculus itself and partly for added skills and knowledge not ordinarily included in the calculus courses. "At the undergraduate level, competence in the theory and use of simple, ordinary differential equations and their applications to the solution of physical problems lies close to the boundary of minimum acceptability of mathematics in any satisfactory engineering curriculum." [1]

[1] "Report of the Committee on Evaluation of Enginering Education." JOURNAL, Vol. 46, No. 1 (Sept., 1955), p. 36.

Minimum Levels

The establishment of a minimum level of performance in mathematics is usually the responsibility of the department of mathematics in the form of required courses. It could conceivably be established by including some mathematical instruction in the various courses in engineering. "However "(in the words of the Evaluation Committee)," few engineering courses are taught in a manner to make significant contribution to the student's knowledge of basic mathematics, nor is time available for this purpose." The Committee goes on to say, however, that "The engineering sciences and subsequent professional subject matter should be developed by making effective use of such mathematical proficiency and should be taught by staff members who have this proficiency."

It is also being proposed that undergraduate engineers should be introduced to many of the areas of modern mathematics. These concepts include mathematical logic, the axiomatic method, theory of sets, number systems, determinants and matrices, group theory, vectors and vector spaces, and other aspects of modern

algebra. The amount of this material to be included and its location in the curriculum are still uncertain, but the importance of many of these concepts to the solution of engineering problems is recognized. Both engineers and mathematicians are interested in finding a satisfactory way to insure the young engineer's competence in areas represented by these concepts.

Maximum Levels

The maximum amount of mathematics needed to study and practice engineering, we might say, is limited only by the field of mathematics itself. Almost any concept or theorem developed in the field of mathematics eventually becomes useful in the solution of some physical problem. Often this use comes unexpectedly.

For example, the theory of games and linear programming have become vital in the solution of many production and distribution problems in industry. Numerous other examples could be cited. It is also a fact that much of the research in basic mathematics is actually directed at the solution of some physical problem which industry needs to solve. For example, much of the research on switching circuits or relays done at the Bell Telephone Laboratories and in other places, which involves adaptations of matrix theory and Boolean algebra, came about because of practical needs in this industry.[2]

It is true that much of this work is at present being done by mathematicians known as *consultants to engineers* or *applied mathematicians* and it is probable that this type of arrangement will continue. It has been suggested that the term "mathematical engineer" be applied to the person "concerned with the advantages and disadvantages of the various (mathematical) methods, and with the choice between them in particular situations." [3]

An example is the engineering computation which is concerned "with how best to choose steps or procedures to obtain the desired results with relatively small expenditures of effort or money." In such situations it is possible for the engineer to avail himself of concepts in mathematics much beyond his own knowledge of the field. In contrast is the mathematician who is concerned with what happens as a result of the various computational steps or procedures.[3]

Modifications to be Considered

There are several possible modifications that can be made in mathematics as taught to engineers. A number of these changes will be listed here.

(1) A change in organization of subject matter from a traditional, compartmentalized grouping to one in which the subject matter is essentially the same, but is carefully integrated and related. In such a course, materials from different areas may appear side by side or may even be included under a single section. An example is the discussion of algebraic and trigonometric equations together.

This is called integrated mathematics, and many examples exist in current text books. A single course or book in mathematics may include

[2] Franz Holm, "Some Mathematical Aspects of Switching." *The American Mathematical Monthly,* Vol. 62, No. 2 (Feb. 1955), pp. 75–90. See also S. H. Washburn, "An Application of Boolean Algebra to the Design of Electronic Switching Circuits." *Communications and Electronics,* Sept. 1953, pp. 380–388.

[3] See J. W. Tukey, "Mathematical Consultants, Computational Mathematics and Mathematical Engineering." *The American Mathematical Monthly,* Vol. 62, No. 8 (Oct. 1955), pp. 565–571.

subject matter from all of the traditional courses of algebra, trigonometry, analytics, and the calculus. One of the first examples of such an integration appeared in the two volumes on *Mathematical Analysis* by F. L. Griffin. It is also possible to integrate college algebra and trigonometry into a single course which can be followed by the two traditional courses of analytics and calculus or by a second integrated course of analytics and calculus. There are also books in these fields.

Integrated Courses

These integrated courses have some advantages and some disadvantages. Among the advantages are the natural ones of seeing related topics discussed together and thus being able to realize that the same rules and theorems usually apply all through the study of mathematics.

It is also possible to get a truer picture of a concept when the student has the advantage of viewing it as it appears in several areas. For example, being able to use the idea of maxima and minima will be of considerable value in drawing the graphs of various sorts of functions, a topic which usually appears first in algebra or trigonometry.

Some of the disadvantages are that the books and courses are shorter than traditional ones and may therefore be more difficult. Also, and for the same reasons, less drill material is included, so that students with weaker backgrounds may not acquire needed skills.

Another disadvantage is the inflexibility of the course. When a student has begun a course in mathematical analysis that covers three or four semesters, he may be at a distinct disadvantage if he transfers to another institution having other kinds of courses or even using a different text book. Students transferring into college may have the same sort of difficulty. This is a very real problem in many of the large midwestern state institutions.

(2) A second sort of modification advocated by many and practiced by a few is the exclusion of some of the traditional subject matter of college mathematics so that more time can be spent on topics considered more important or on new topics not now in the curriculum. There are many places where such cutting can occur, but not much agreement on what should be done.

An example is the omission of Horner's Method for solving equations of higher degree. This can be replaced by a much shorter and probably more meaningful discussion of graphing and interpolation; another topic for omission, but one not accepted by all mathematics teachers, is the law of tangents.

(3) A third suggested modification is something like the second, but stated positively says that some of the modern concepts of mathematics should be introduced into undergraduate college mathematics for engineers. This implies, of course, leaving out some of the things usually included in engineering mathematics. This has been discussed fully by a number of writers and need not be developed here.[4]

(4) The last method will necessitate teaching more and better mathe-

[4] "The Experimental Freshman Program at the University of Kansas." G. B. Price. See also E. P. Northrop, "Modern Mathematics and the Secondary School Curriculum." *The Mathematics Teacher*, Vol. XLVIII, No. 6 (Oct. 1955), pp. 386–393; and Saunders MacLane, *The Impact of Modern Mathematics. Bulletin of the Na-*

matics in high school; this modifies mathematics for engineers by starting further along with entering freshman. In terms of the traditional mathematics curriculum, it means beginning with analytics or with analytics and calculus. This is, of course, standard practice in many eastern colleges and universities and in some others over the country.

It can be used at any engineering college which includes enough entering students who have had a good four year high school course in mathematics. If the college of engineering requires the same number of hours in mathematics, the student will get further in the field, while if the number of hours required for graduation is decreased by giving advanced standing credit on college algebra and trigonometry, the student will be able to graduate sooner.

There are many high school students capable of taking advantage of such an opportunity, and it is possible in a number of colleges to enroll in such courses. This keeps the student from having to repeat courses, and fosters good habits of study, whereas he is otherwise likely to fall into the habit of loafing which will affect other courses he may take later.

Possible Objections

Objections to modification can probably be summarized under three headings. First, the traditional offering is the best because it has stood the test of time. This attitude is probably due to lack of knowledge of the more modern concepts in the field of mathematics and of the ways in which mathematics is used in modern science and engineering.

tional Association of Secondary School Principals, Vol. 38, No. 203 (May 1954), pp. 66–70.

Second, many college mathematics teachers have had no opportunity to learn anything but the traditional mathematics and hence are unable to make modifications. Since the college curriculum on the undergraduate level, even now, is essentially what it was fifty years ago, teachers who did not take second or third year graduate work may know little about modern mathematics. Many of these teachers are willing to make modifications in the mathematics they teach, but do not have the background.

It is true that in recent years many of the colleges and universities have modified their own curricula and are thus showing ways in which this can be done, as well as turning out students who have learned these concepts. Summer institutes and conferences of various sorts sponsored by the National Science Foundation, private foundations, and industry are reaching an increasing number of college teachers and giving them some background for revising the presentation of college mathematics. These do not go far enough, however, since the time is short.

Another feature not well worked out in these institutes is the actual illustration of how modern mathematics can be integrated into the college curriculum. The National Science Foundation Institutes include excellent lectures on phases of modern mathematics given by prominent mathematicians with a recognized ability for exposition, but they have not included specific ways in which modern mathematics can be introduced into the college curriculum. This can be done on a college or university campus by a well-trained mathematician if given enough time. However, in the small college, where such revision is probably needed

most, the mathematics professor usually has neither the training nor the time. Help and time may be provided at the summer institutes.

A third objection to the modification of the subject matter of mathematics for engineers may be the result of an honest doubt about the effectiveness of the newer concepts as compared with the older ones. This often comes from mathematicians who are well acquainted with the field of mathematics and its applications to science and engineering.

They may reason as follows: because engineering students, especially at the undergraduate level, are still expected to solve problems and do extensive manipulations, these things will have to be taught in the mathematics classes. For more advanced work in engineering study and research, more modern concepts will be needed, but these can be acquired in advanced courses in mathematics before the need for them arises.

Objections by enginering instructors to modifications in mathematics usually take the form of (3) discussed above, or perhaps of (1), and for the same reasons. If they think of engineering as it has traditionally been taught and practiced, then traditional mathematics is adequate and should be retained; if they think of modern engineering, then the few who take advanced work and do an advanced type of engineering work can acquire the mathematical concepts and techniques needed in the graduate school by taking advanced courses in mathematics.

For example, a civil engineer may face problems quite different from those of engineers in other fields. Quoting from Professor B. A. Whisler, "Specifically, the current proposals for changes in engineering curricula take the form of requiring additional courses in higher mathematics and physics and other additions of this nature. Such changes are necessary for students who will later work in fields which require this specific background, but for the civil engineer such courses are of little significance. Because of the type of work he does, there are many other subjects of much more importance to the usual civil engineering graduate."

"The civil engineer, whether in the field of design, construction, or maintenance, deals with a much greater variety of materials than does any other engineer. . . . Hardly any institution in the country covers these materials adequately at the undergraduate level. There was once a time when the coverage was better, but in recent years the study of materials has been neglected in order that new subjects might be added to the curricula; subjects which only rarely have direct application to the work of the practicing civil engineer."

"Similar arguments could be made for the need for a greater study of labor relations, accounting and other subjects. Most civil engineers could profit by such studies and would find them much more useful than the study of differential equations and atomic physics." [5]

Recommendations

In view of the above discussion, the following suggestions are made about modifications of mathematics for engineering students.

(1) Start the student as far along in mathematics as he is capable of going. This may be in analytics or perhaps in some instances in the calculus. It is probable that some reward like advanced credit in the elementary courses will add more incentive for the student. Many a serious

[5] B. A. Whisler, "How Should we Educate Civil Engineers?" JOURNAL, Vol. 45, No. 2 (Oct., 1954), pp. 144–145.

student, however, will be glad to satisfy equivalent hours by taking electives in mathematics or other areas in which he may be interested.

(2) Modernize the subject matter in mathematics. This can be done by giving a completely reorganized course, as suggested by a number of mathematicians, or it can be done in a more modest way by teaching the traditional subject matter from a somewhat different point of view.

Examples would include a much more rigorous definition of variables, to avoid certain misunderstandings that arise in quite elementary problems, such as the negative answer $x = -9$ found when solving the problem "Find the length and width of a rectangle whose length is 2 inches more than the width and whose area is 63 sq. in." This also avoids unlearning the definition at a later stage in the study of mathematics and science.

A second illustration is a more complete discussion of the number systems of algebra, including the binary number systems. This furnishes a much sounder basis for the study of complex numbers and computational mathematics.

(3) Integrate the subject matter of mathematics to such an extent that the students will get the idea that all mathematics is built on a logical basis and involves undefined terms, definitions, postulates, and theorems proved from these, using the accepted rules of logic. Some consideration will have to be given to flexibility, so that the courses can fit into the situations that exist in the schools of the area. The idea that mathematics is a unified subject, however, dependent on definite rules and patterns of thought, is a fundamental and this idea should be instilled in every mathematics student.

(4) Consider the misgivings of the engineers about needed skills and concepts from traditional mathematics as well as the need by their students of advanced courses in mathematics. It seems reasonable to recognize that the amount and type of mathematics needed varies with the different fields of study and the level of study of engineering. It also seems advisable that certain types of courses and subject matter be made available so that engineering students who recognize the need can take such offerings. Three such areas are statistics, the basic principles of quality control, and the computational mathematics mentioned earlier in this paper.

(5) Encourage engineering professors to teach the use of mathematics. This is being done, of course, in many instances, and such a practice generally will strengthen both the mathematical and the engineering knowledge of the students.

The current emphasis on the improvement of mathematics and science teaching and the attempts to get more students at both the high school and college level interested in the study of mathematics, science, and engineering make it imperative to modify the curriculum in mathematics if this will make teaching more effective for learning and motivation purposes. New concepts have been developed in the field of mathematics; old concepts have been sharpened and redefined and thus made more useful in learning and understanding the mathematics that must be used by scientists and engineers. Our students should have the advantage of these new ways of thinking and working in the field of mathematics. It is the task of the mathematician to devise ways in which this can be included in the mathematics curriculum at all levels.

A TEACHER INTERNSHIP PROGRAM

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Introduction

The "Quality of Instruction" Committee of the Air Force Institute of Technology (AFIT) studied the question: "What assistance can be given to a young instructor to become an effective teacher?" and evolved a recommendation for a "Teacher Internship Program." The committee was composed of G. R. Graetzer, Head, Department of Aeronautical Engineering, Chairman; W. S. Ericksen, Associate Professor of Mathematics; and R. S. Basham, Captain USAF, Instructor in Electrical Engineering. The Institute of Technology provides Air Force officers with an education tailored to meet specific Air Force requirements in specialized fields of engineering and business administration; the Institute is ECPD-accredited and grants Bachelor's and Master's degrees. Although the recommendations of the Committee were developed primarily for AFIT, they may also be adaptable for use by engineering schools in general.

Reason for the Study

College teaching is probably the only career into which a scientifically trained young man enters without previous apprenticeship. Although traditional, this is certainly undesirable. Not only does the quality of teaching suffer to the disadvantage of the student and the school, but it is embarrassing for the young teacher, who has to find his way for himself without real help.

A search through the literature, especially the ASEE JOURNAL, did not reveal any comprehensive study of this special problem. One reason is perhaps that "Effective Teaching" has never been and possibly will never be clearly defined; however, everybody knows how detrimental poor teaching is, and every enthusiastic teacher tries and will try to improve his teaching. What means are then available for improvement with a minimum of wasted time? To answer this question, a survey was made of practices currently in effect at AFIT and at other colleges and universities.

Assistance Given to Young Instructors at AFIT

(*a*) *No school-wide system.* At AFIT, there is no organized system to help the young instructor make a successful start; the department heads handle this problem on an individual basis. Generally, the instructor is introduced to his co-workers by the department head and presented to the entire faculty during a council meeting. The department head then generally discusses in some detail the courses which the newcomer will teach, the type of students, and the program of the school. The conference is concluded by giving the instructor a copy of the Faculty Manual, a collection of academic and adminis-

trative policies, regulations, and general information for faculty members.

(*b*) *Course files.* In some departments, course files are kept very meticulously. These contain all the reference material used in pre-requisite courses, a detailed day-by-day outline of what has been done in earlier courses of the same number, all quizzes, final examinations, lab reports, term papers, guest lectures, and schedules of visits to installations. Most instructors find such files very useful. In some departments, however, the files give only a very general idea of the content of previous courses and make it difficult for the young man to set up a regular schedule; often, the instructor runs out of time towards the end and has difficulty in covering all the topics which the catalogue prescribes.

(*c*) *Program evaluation.* Grading methods, desirable length and difficulty of quizzes or home problems, and ways to measure student progress are seldom discussed. Although AFIT has had good luck with young instructors, there have also been some complaints about unsatisfactory teaching. The Deans obtain a general idea about teaching quality only when the students submit their evaluation of the school and its program at graduation time. These comments are often helpful since the students are mature officers; but such comments alone are certainly not sufficient to improve the art of teaching.

(*d*) *Suggestions by department heads.* Some department heads occasionally sit in the classes of a new instructor, and have discussions and offer suggestions afterwards; other department heads shy away from this idea and obtain a general impression of the efficiency of a new teacher through occasional remarks by students. No department has an organized system to help the newcomer, but department heads, experienced teachers, and especially new teachers agree that some help should be given in the form of thorough contact during actual teaching hours between an experienced man and the neophyte.

The department head may, in rare cases, depending on both personalities involved, be the proper contact; in general, he is not the right man because of the embarrassment of the new teacher when the "boss" sits in. The feeling of being supervised, and possibly criticized, may induce the new teacher to lecture not for the students but for the superior. This can harm both the students' morale and his own, so that he will give a poorer performance during this supervised hour than when left alone.

Although the method is standard in high schools and grade schools, it is apparently undesirable in colleges. What methods are then being used in other colleges?

Assistance Given to Instructors at Other Colleges

(*a*) *Awards.* The literature on effective teaching shows that awards for good teaching are not too useful for improvement of the art. From one prominent school, the following results were reported on an experiment in which cash prizes were available for the five "best" teachers. Students, faculty members, and fifth-year alumni were asked to select the outstanding teachers. "For the past four years, the resulting selections have shown an almost perfect inverse correlation. In other words, if a man was rated high by one group, he was invariably rated low by the other

two." Therefore, awards for good teaching seem to offer no help.

(*b*) *Workshop.* Another idea has been published in the December 1955 issue of the ASEE JOURNAL. Several committees of the ASEE are to study "the feasibility of organizing an annual summer workshop in which a young teacher who has been teaching a short while, say less than five years, will have an opportunity to prepare for his profession." Although the term "workshop" may not be desirable, the idea deserves attention and may, after some time, lead to good results. Presently, it is too far in the future to be of actual help.

(*c*) *Teaching internship.* Another idea has been published in the *New York Times Magazine* of 18 October 1955, by Dean D. H. Morrison of Dartmouth. The program may be summarized under the title: "Teaching Internship." The young instructor works in association with an experienced professor; they visit each other's classes, discuss objectives and methods, seek light on learning habits and teaching techniques, and jointly act as counselors for a few students. This internship, comparable to that for medicine, seems the only workable and constructive method; consequently, an investigation of the success of this method was undertaken.

Only after an extensive correspondence with various people was it possible to assess the extent of adoption, and to gather some details of this experiment, which has been carried out under the sponsorship of "The Fund for the Advancement of Education." In 1953, the Fund made grants to 15 colleges for a variety of internship programs. Preliminary reports from these schools were encouraging; the final report is expected in the near future and will be a valuable document.

Although the experiment so far has been carried out in Liberal Arts colleges only, there is no reason why a similar system should not work just as well or better in engineering colleges. Therefore, the AFIT Committee finally made its recommendations generally as follows.

Recommendations for a "Teaching Internship Program"

(*a*) *The plan.* The internship is mainly an association of every "intern" instructor of less than 5 years teaching experience with an experienced "guide" teacher of high reputation, and consists of continuous intervisitation of classes by intern and guide, with personal discussions both after class and later.

Application to *every* young instructor removes the feeling of the newcomer that he is under special "control"; the purpose is not control but rather friendly guidance, assistance, and cooperative relations between the two team-mates. *Continuous* intervisitation is necessary in order to scrutinize all teaching situations occurring over many weeks.

The discussions afterwards will be the most valuable part of the program; they should be held between intern and guide, between all the interns, or in any other combination, should often develop around the coffee table, and should be just as valuable and educational for the experienced teacher as for the newcomer.

A seminar with an appropriate guest speaker should be given once or twice per term, offering an opportunity to discuss problems of learning, of teaching, over-all educational theories, and guidance psychology.

Every newcomer should be given an introduction to counseling. Counseling gives the young teacher a chance to become acquainted with student problems, how and why people learn, why they like or dislike certain courses, and what encourages or disturbs listeners. The reports reviewed stress counseling as extremely important; "it is too often forgotten that a teacher, as well as a student, can contribute to academic failure."

(*b*) *The coordinator.* The program should be organized under the supervision of the dean, who should appoint an internship program coordinator, preferably one who is interested in its success and is authorized to devote the time required.

This coordinator must overcome the initial inertia which opposes any new idea; however, he also has various other duties. He should prepare the announcement of the program in the school catalogue. This eliminates a possible surprise to the newcomer, who with proper presentation may consider the plan a very attractive asset of the school. The program should be announced as *available* at the school, not as mandatory.

Further, the coordinator should determine the starting time and length of the program, after consultation with the dean, department heads, and instructors, should keep in close contact with ASEE and with colleges which have already such systems, and should arrange for visits by faculty members to some of the participating schools for further details. The coordinator should also prepare regular progress reports.

These reports, to be submitted to the Faculty Council within 30 days after the end of each term, should by no means contain any comments on individual instructors and their performance, but should evaluate the usefulness of the *program* as a whole and recommend implementations. The few rules established should be considered as experimental, tentative, and flexible.

(*c*) *The teaching load.* The extra time required for the program must be provided by decreasing the teaching load of interns and guides, possibly by as much as 25 to 50%. The teaching load of the newcomer should not exceed two sections of one course during the internship term. This makes it possible for him to prepare himself thoroughly for his own classes, to sit in the classes of the guide, and to have time for discussions.

The first teaching assignment for the newcomer should be chosen by the department head, after consultation, to require a minimum of scientific preparation as far as this is possible in the over-all program. The assigned course may be a very elementary one, a medium level offering, or an advanced course.

Very often, a man fresh from college, possibly immediately after having obtained the professional degree or Ph.D., can much better teach an advanced course than a low-level course. Even experienced instructors often have difficulty in adjusting their teaching to undeveloped students.

In many cases, however, the newcomer may prefer to teach an introductory course first to get a good foundation. The department head should discuss these matters with the intern, guide, and coordinator. Graduate teaching assistants should be considered in the load-distribution plan of the department; they will also be prospective interns.

Summary

The Committee is convinced that not enough has been done in the past to assist young instructors in their teaching careers. The Committee therefore recommends an internship program, consisting mainly of class intervisitation for at least one full term between any newcomer of less than five years teaching experience and an experienced instructor, but also of discussion periods, seminars, and counseling of students.

Such programs exist at a few other colleges and have been successful. They improve the art of teaching and the self-confidence of the young instructor, his interest in the school, and in his teaching career. As a very important side line, they help the experienced instructor to re-evaluate his methods and deepen his own interest in teaching. The Committee believes, in short, that such programs are well worth experiment, and should be extended to other colleges.

INSTITUTE ON COLLEGE ADMINISTRATION

The annual Institute on College Administration for presidents, deans, and other administrative officers will be held at the University of Michigan, July 15 to 19. Major themes to be covered in the program of the Institute include problems and trends in higher education, curriculum planning and administration, human relations factors in personnel administration, student personnel problems, and purposes of higher education and their implications. Outstanding resource authorities will make presentations during the morning sessions and participate in the afternoon discussion sessions.

Those attending will have an opportunity to help determine specific topics and problems to be discussed. Special attention will be given to the use of institutional self-studies, and individuals will be able to consider problems or topics of special interest to them or to consult with the administrative and professional staff of the University.

The Director of the Institute will be Algo D. Henderson, Professor of Higher Education, and the Assistant Director will be James M. Davis, Assistant Professor of Education and Director of the International Center at the University. Additional information can be obtained from Professor Algo D. Henderson, 2442 U. E. S., University of Michigan, Ann Arbor.

AN EXPERIMENTAL THREE-YEAR STUDY OF EDUCATIONAL METHODS IN CREATIVE DESIGN

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It is the belief of a few educators and many engineers in industry that more attention should be given to synthesis and creativeness in the engineering schools of the nation. Support has been lent this view by the organization of the Evaluation Follow-Up Committee with a division for analysis and creativity.

The sense in which creativeness will be used in this paper is, in essence, a systematic evolution from one's own thoughts or imagination to originate or invent intentionally a new predetermined item of hardware or complete system by a process of reasoning, utilizing engineering tools and techniques.

Many papers (see References) have been written concerning creativeness in engineering and the teaching of creativeness in technical schools; however, few institutions have experimented with techniques and methods of approach to developing creativeness in the student. Three such attempts have now been made in the School of Aeronautical Engineering at Purdue University.

Initial Stage

The first, in the spring of 1954, utilized the aircraft engine design class (a senior level course) organized as a unit to simulate the design department of an industrial organization. Working as a team, students designed a small reciprocating engine and submitted a detailed report proposal of their analysis and recommendations to a committee established to represent management.

This committee then examined and discussed the proposal and presented their decision to accept or reject the project. During the semester, several engineering staff members participated as consultants on problems within their respective fields of specialization. This served to help the students over difficult hurdles and to lessen the frustration of attacking unfamiliar problems.

Findings and results of the program were encouraging, and created considerable interest in industry as well as among staff members who participated. It was therefore felt that further investigation was warranted. A report covering the results obtained during the spring semester of 1954 was distributed to a number of key engineers in industry. The response to this report also emphasized the need for continued exploration.

Second Stage

Further experimental studies were undertaken in the spring semester of 1955, with the objective of exploring, further, methods of self-learning and of applying the scientific and technical knowledge to the evolution of new products. To provide advanced

technical knowledge in aircraft engines, as well as to introduce new engineering techniques and methods which had not been previously provided, a new aeronautical engineering course was established. Specialists from various related fields participated as guest speakers and consultants in a carefully organized schedule which gave the students a broader insight into these related areas.

Two practicing engineers from industry were included as part of the management group, and both contributed considerable effort towards emphasizing the need for a more realistic approach to engineering problems. To supplement the material in available textbooks, considerable emphasis was placed on the techniques of library research, technical reports and articles, and methods of self-learning. Other than these major changes, the second semester was conducted in a manner similar to that of the first.

The conclusions reached through the efforts of the second semester confirmed those of the previous one—in particular, the findings pointed up the need for more attention to economic factors, to technical sketching, and to various other methods of spatial visualization. There was also sufficient evidence to sustain the argument that success in teaching creativeness must be gained through organized experimentation.

Third Phase

Early in January, 1956, a Design Education Sub-Committee was established to organize the forthcoming aircraft power plants courses for the spring semester.

One of the first problems confronting this committee was the selection of a semester problem for the class. It was readily recognized that the committee must provide a challenging objective for the students, involving features that would develop resourcefulness, initiative, and technical knowledge—a problem that would be difficult, yet not insurmountable.

After considerable deliberation and investigation, an engine of the 300 horsepower class for helicopters was selected as a basis for the class project. Such a plant must be extremely dependable, have rapid acceleration characteristics, gear reduction to allow low rotor blade speeds, maximum power output for extended periods, and high torque characteristics at low speeds, all of which provide problems requiring many compromises and complex engineering decisions. The problem was presented to the class in the form of a simulated Air Force "Invitation to Propose," and was phrased so that the students could decide the type of engine they felt would best meet the specifications and requirements.

Previous experience has shown that one of the first criteria for teaching a student to do creative work is the building of student courage, confidence, and willingness to attempt something that has not been systematically or completely outlined. It was decided, therefore, to stimulate student initiative by dividing the class with members chosen alternately. Each team then elected a Chief Engineer.

The two groups worked independently and met together only when a lecture was given by the Instructor. The competitive system generated a tremendous amount of interest and enthusiasm. Each group worked secretly and was cautious that its ideas

and designs were not "leaked" to the opposing group.

In the first few weeks of the semester, extensive library research was undertaken by each group, and individual ingenuity was utilized to confirm decisions in selecting engine type.

Each team decided to design a gas-turbine engine coupled through gearing to the helicopter rotor, but here similarity ended. One group was, essentially, more conservative in its design decisions. This may be attributed to the fact that several members of this group were more mature students than the average. The other group had a tendency to do more progressive planning than their conservative competitors, even though "prior practice" material was not available for comparison. Both groups, however, attained reasonable and sound engine designs—although time did not permit complete specification drawings.

Other Aspects

One method that was earlier recognized as an aid in teaching creativeness was the inclusion of the industrial approach of assigning groups of specialists to cooperate on the handling of complex problems. There were two phases to this part of the program: (1) each group organized as a team with students choosing their own particular areas of interests; (2) specialists among the staff members offered their services, to show the students how consultants and specialists contribute in the solution of design problems. Thus, the students were able to see that all types of professional backgrounds are important and necessary to evolve a complex product.

It is felt that the use of a gas turbine as the design problem was an important factor in stimulating interest. At the beginning of the semester, the committee had been somewhat hesitant in permitting the use of this type of product as a basis for the designs, reluctance being due to the scarcity of design data on which the groups could base their decisions. However, the keen interest more than outweighed limitations from lack of data on prior practice, and demonstrated that the selection of a product which appeals strongly to students is an important advantage for courses of this type.

Another stimulant to the students was their realization that, at the end of the semester, they would submit their findings and recommendations to "Management." This situation, along with the knowledge that their design proposals would be presented and evaluated on a competitive basis, was sufficient to maintain a conscientious attitude without prodding from the instructor.

Expression Important

As previous experience had indicated, envisioning and proposing possible configurations for the engines, and spatial visualization of the proposals so that other members of the teams could contribute ideas for improvements, proved the greatest hurdles for the students. This appears to result, at least in part, from concepts and attitudes acquired in earlier courses. To make room for an expanded treatment of mathematics and the physical sciences commensurate with the increasing recent importance of these areas and tools of technology, most engineering curricula have downgraded, and in some cases virtually eliminated, courses in drawing and visual or graphical methods of

communication. As a result, the students tried to analyze the situation before they had the problem defined, and they had the attitude that any kind of drawing was sub-level work for engineers.

Correction of these weaknesses has consistently proved to be the most difficult phase of the design course. Only by persistent and repeated urging and by using many illustrative examples of how to propose arrangements for the engines could the students be made to realize that the situation must be defined before it can be analyzed. It required the greater part of the semester to convince the students that three-dimensional sketching is a powerful feedback stimulant to further ideas, as well as a necessary means of communicating proposals on complex parts to management or others who must decide on further action.

Sketching for Creative Work

In creative work pertaining to complex and irregularly shaped parts and systems, sketching is, of course, essential, and it is to be expected that considerable time and effort must be expended in developing this ability. But the real hurdles were not the lack of ability to sketch. Rather they were (a) the "unlearning" of preconceived notions such as the belief, apparently acquired in earlier courses, that all engineering work can be adequately handled merely by choosing the right formula and solving for the answer, and (b) getting the students to believe that they actually could make three-dimensional sketches.

This last, after the student is finally convinced that sketching really is important, appears to be a psychological factor. A man with defective eyesight is not averse to wearing glasses, but those who must wear hearing aids usually go to extremes to conceal them. Similarly, a poor penman has little aversion to writing, but people who do not have artistic ability stubbornly resist any kind of drawing.

Why people are this way, we do not yet know, but the fact that most of them are seems to be highly significant, and it represents a most important concept in the effective teaching of synthesis. As evidence, once these situations were recognized, taken into consideration, and surmounted, real progress was made in the creative aspects of the work, and, during the last month of the term, more was accomplished than had been in the preceding three.

The foregoing strongly suggests that more effort in earlier courses to give students an insight into the real nature of engineering, to make them realize that systems synthesis as well as systems analysis is essential in modern technology, and to avoid giving them the feeling that sketching is unworthy of their time and attention, would contribute greatly to their progress toward becoming well-rounded professional engineers. Such efforts do not necessarily require additional courses. Rather, they should be integrated into existing courses.

For instance, mathematics is introduced early in the curriculum and then used in *practically every technical course that follows.* If spatial visualization through carefully drawn sketches (with perspective, isometric, and dimetric grids as aids to the development of ability) were similarly handled, the value of this powerful aid to creative thinking and to communication would be recognized, and much less time-consuming reorienta-

tion of student attitudes would be required later.

Conclusions

Observations and findings during 1956 agree with and sustain conclusions reached in 1954 and 1955. Hence, it is believed these can now safely be used as "guiding rules" for organizing and conducting creative design courses and for generally effecting a better balance between synthesis and analysis in our technical education program:

1. Creative design courses belong in the senior year, where they can draw on the student's previous three years of fundamental studies in mathematics, the physical sciences, economics, and the various methods of communication. Also, to obtain maximum value from courses emphasizing the *use* of knowledge, the student must have reached a level of maturity that seldom is attained before the senior year.

2. Creative design courses should not be regarded as replacements for the so-called fundamental engineering courses. These basic courses are still the "foundation stones" for an engineering education. But alone, especially when they disregard synthesis, basic courses leave the student with a somewhat distorted notion of the real nature of engineering.

Also needed is the stimulus that comes from joint effort to achieve a comprehensive goal, and the broad insight that is the basis for the development of sound judgment. Thus, curricula that culminate in a well-handled course that stresses self-learning, teamwork, and judgment offer a better balanced preparation for professional engineering work.

3. The psychological aspects of creative courses are important and must be understood by teachers of such courses. Courage to "get off the beaten path" is latent in most students, but it does not develop in a negative atmosphere. Thus, success is heavily dependent on the constructive and encouraging attitude of the instructor.

4. Proper guidance in the selection of a project is quite important to success in a creative design course. Almost any type of complex product will illustrate development procedures, but real enthusiasm and desire to accomplish will develop only if the selection is within the student's chosen field of interest. Failure to recognize that students learn in proportion to their desire to learn is almost certain to limit accomplishment in a creative design course.

5. Where the number of students involved will permit, division of the class into competing teams is very helpful in stimulating initiative, enthusiasm, and self-teaching. This aids in reducing the effort that the instructor must expend toward insuring adequate coverage of the subject, and it may indicate a partial solution to the large enrollment problem that most technical schools are now or soon will be facing.

6. The requirement of submitting a design proposal report to management is a powerful stimulus. Advance awareness that management will include some prominent engineers from industry who will be free to challenge anything the students propose also very favorably affects the quality of the work and the thoroughness with which it is done. This further contributes to easing the load on instructors faced with large classes.

7. Greater use of graphical synthesis and of technical sketching in connection with the presentation of presenior courses, and, in particular, less down-grading of graphical tools and methods of communication, would greatly reduce the amount of time that must now be expended in overcoming student prejudices and misconceptions about the need for synthesis and the importance of spatial visualization.

8. Results of this three-year experiment indicate that the cooperative method in design courses offers several advantages:

(a) It more clearly indicates the situations that graduates must face. Advance knowledge of these conditions should aid in easing and shortening the period of adjustment to industry.

(b) It is effective as a stimulant to learning.

(c) It provides a fuller opportunity in learning how to work with people and develop leadership qualities.

(d) It aids in the development of resourcefulness, one of the most valuable characteristics an engineer can possess.

(e) It aids students in more fully determining the kind of work for which they are best suited.

(f) It broadens the students' perspective and background.

(g) It aids the students in developing the ability to *use* their basic knowledge.

(h) It helps to identify engineers with unusual capabilities in creative engineering design, and so should aid industry in the never-ending search for the creative talent that is the catalyst in our modern economy.

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Come to Cornell!

A TEACHING EXPERIMENT WITH PROBLEM SOLVING

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Student motivation plagues every teacher who has the slightest concern for his subject and his students. Approaches to the problem vary. Some instructors seem to feel that student interest varies directly with vocal loudness. Others turn the classroom into a circus ring. Many become so involved with techniques calculated to increase student motivation that their courses degenerate into a frantic display of audio-visual aids.

This paper, by contrast, discusses an academic experiment in the use of the "*research problem*" as a method of gaining and maintaining a high level of student motivation. From the start, it must be understood that this teaching device is not meant to replace other methods, but merely to supplement them.

The Social Science Department of the Georgia Institute of Technology offers a course in Public Opinion and Propaganda. Intended primarily for juniors and seniors, the course must be covered in one quarter, approximately eleven weeks. In general, it is calculated to instill an understanding of the basic nature of public opinion, and to examine briefly the manifold and complex forces evident in its formation. Students also examine typical propaganda techniques, and are expected to gain at least a nodding acquaintance with the mass media of communication.

The purpose of such a course in a school largely devoted to technological learning is two-fold. First, it is widely recognized that students of the physical sciences are apt to be deficient in understanding the nature of their fellow men. Because a study of public opinion and propaganda must consider the behavioral characteristics and reaction patterns of human beings, individually and collectively, it follows that the student can learn much about human behavior.

Second, success of the engineer and designer depends (more than he usually realizes) on his ability to convince the people with whom he deals that his particular ideas are valuable. While this course makes no attempt to produce accomplished propagandists, it does attempt to equip the student with an understanding of how ideas can be presented in persuasive fashion. Such knowledge is of direct value to the engineer in his professional career.

The wide scope of the course, its dual nature, and the extreme rapidity of coverage necessitated by the time limit of eleven weeks, seemed to demand that the lecture method be used as the fastest possible way to cover the ground. As a result, the subject was first presented as a series of lectures, with limited class discussion. While student reaction indicated that the course was not unsuccessful, the

class atmosphere did not have the energetic spirit every teacher can recognize when student and instructor alike are highly motivated. As a result, it was decided to reorganize the course to increase the level of learning and to stimulate student interest.

It seemed that both these objectives might be met if the course material could be closely integrated with the student's major interest, engineering. Previously, engineering subjects were related to public opinion and propaganda only by the rather intermittent use of examples and illustrations taken from the experiences of engineers. The question of how to accomplish the integration of highly dissimilar subjects remained.

After some thought, the utilization of the "research problem" appeared to meet the requirements. Specifically, the student was told that he must invent an object or a process. The invention must be a genuine departure from current practice, not merely a minor modification of objects or processes already in use. Furthermore, the invention must depend completely on techniques and materials currently in use. That is, the student could not employ imaginary manufacturing methods, materials, or power sources, in the conception.

Once the student selects an idea that appeals to him, he is faced with two very different, but related, public opinion-propaganda problems. First, he must persuade a potential manufacturer to produce the product. Second, he must devise and implement a propaganda campaign which will sell his product to potential users.

The dual nature of this requirement highlights the different propaganda appeals necessary. In general, the manufacturer must be approached with solid technical and economic information. On the other hand, the effectiveness of modern advertising is adequate testimony to the fact that consumers are rarely interested in technical matters, but rely instead on appeals to the emotions.

Student reaction to this general problem was astonishing. The highly complex nature of the exercise was immediately recognized, and the total research problem was broken down into its component parts. Without exception, students attacked and solved all questions of the technology of their inventions.

This was to be expected in a technological school, but it was not expected that they would research the industry involved to pick out the optimum manufacturer for their product. In addition, they studied comparable objects or processes to arrive at reasonable cost figures, checked the cost of advertising in the various mass media, estimated the size of the audience reached by each medium, and correlated this with the potential market for their invention.

Professors were consulted when the invention demanded knowledge outside the student's area of specialization, and some students even concerned themselves with problems and techniques of the manufacturing process in order to present a complete argument to a potential manufacturer. The local offices of the Bureau of Labor Statistics and the Department of Commerce cooperated by making available their own market analyses.

Even local representatives of major industrial concerns devoted time to discussions with individual students about the feasibility of inventions, the need for certain types of products, and probable costs of production.

Finally, professors and students in the field of Industrial Design consulted with individual class members about the attributes of "good design." All this was done in a three-to-four-week period during which normal classwork was carried on as usual.

Classroom response was enthusiastic. Discussions of the theory of public opinion and propaganda were given rapt and critical attention. Students applied the "test of theory" to their solutions, with the result that the final presentations were comprehensive and well-considered. Propaganda appeals ranged over the full scope of theory, including, it must be admitted, appeals which do not represent the best of American advertising art. (As might be expected from a class of college-age males, there was some overemphasis on sex as a device to attract consumer interest.)

The inventions themselves mirrored the interest and imagination of the students. Of the first two dozen, three are currently being patented: a radical re-design of the axles on large truck-trailers, a moisture-proof pocket container for pills, and a new method for capping toothpaste-type tubes. A new mechanism which will cut the cost and speed the process of handling large quantities of pipe has already been installed by an Atlanta firm. Other items, equally worthy of production, include a standard box camera which will accept four different film sizes, a machine that will crochet, a device that automatically shuts off water and prevents overflow in a sink or bathtub, an attendantless all-night gasoline station, and an efficient low-power gasoline turbine, to name only a few. All of the designs mentioned appear to be economically feasible and to meet current needs.

The results of this experiment have been most gratifying. Student comprehension of the complexities of public opinion and propaganda has been extraordinary, considering the time limitation on the course. It has not even been necessary for the instructor to give more than the most cursory treatment to the "mass media" since the students undertook such study on their own as an assumed part of their research problem.

The course is conducted as a seminar, with the total enrollment in any one section limited to fourteen. This allows the class to criticize each paper presented. Not only does this insure good group participation, but it also tends to broaden the actual subject matter covered, since students are not shy about adding their own propaganda ideas during the discussions.

As a method of teaching, the research problem is not a cure-all. It puts great demands on the teacher since he must familiarize himself with many subjects normally outside his range of knowledge. The method is, however, adaptable to courses in almost any field of study, and seems to lend to the subject a sense of current urgency which, in turn, leads to a high degree of student interest. Above all, the problem approach results in enjoyable and stimulating classes, for the teacher as well as the student.

Come to Cornell!

THE AESTHETIC FUNCTION OF ENGLISH COMPOSITION

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A paper presented at a joint conference of the Engineering Drawing and English Divisions on June 26, 1956, Ames, Iowa

Of all the required courses in the curriculum, English composition, as usually taught, seems to yield about the lowest return for the effort expended. Though everyone agrees that it is essential, in most places it is hated by students and faculty alike. Publishers run their presses overtime to provide new handbooks, new books of exercises, new anthologies of "models," new correction charts, all bright and shining in two or three colors with every typographical device known to man. Yet it still remains the same old course, in which students hate to write and teachers hate to read—and both of them with good reason. Until we change this situation we shall never make much progress.

The main reason, I think, why we do not produce better results is that we have set our sights too low. Are we, especially in engineering colleges, teaching English composition as one of the humanities, or do we consider it a purely utilitarian subject? If the latter, then we are failing in our duty.

For, by the nature of things, the English department should be the center of general education in the college. To lower ourselves to the status of hacks drilling in grammar, spelling, and punctuation, with a smattering of the external forms of correspondence and technical reports thrown as a sop to the engineering faculty, is to debase our function. If we are worth our salt, we must teach the *art* of writing. But I sometimes wonder whether we all understand what that phrase connotes.

Art versus Craft

There is, of course, no sharp distinction between an art and a craft, but there is a real difference, at least as I am using the words here. A craft, in my sense, is a body of techniques which, when properly applied, produce easily predictable results. If the lathe is in good condition, if the operator is properly trained, and if the material is good, the products will be identical and perfect—as judged by the micrometer, not by a subjective critic.

An art, on the other hand, uses a body of techniques to create not an end product, but a middle-stage product which continues the process by affecting a human being. The result of the artistic process is, therefore, never perfectly predictable, since human beings never are. Recently I read Thomas Mann's early novel *Buddenbrooks* for the first time, and found it, for me at least, a beautiful thing. Yet the same author's *Dr. Faustus* left me cold a few years ago. Many musicians love Mahler's music, yet Olin

Downes always thought it "vulgar." What looks like a great painting to one man may seem nothing but blobs of pigment to another.

In one case the artist has reached his object; in the other, using the identical middle product, he has failed to reach it. His end product is, to use a much-abused word, communication. And despite all the interesting work of the information theorists, communication on anything but the most elementary levels is still an art, not a craft.

Indeed, the whole of living is mainly a large extension of the art of communication. In almost everything we do we are concerned not with techniques *per se,* but with the effect our techniques produce on other men. Why else should we expend so much time on what information theory calls "redundancy"? Simple nursery tunes are "somewhat more than 50% redundant" and "the best paintings are 98% redundant," to quote from a recent *Scientific American* paragraph, though I should like to know what determines the "best" and I confess that the percentages convey no exact meaning to me.

In this area, surely, we must question the sanctity of numbers, even though that be heresy in an atomic age. For I suspect we shall some day find that even electrons and protons possess individual differences. And then what will happen to our modern mystique of numerology?

Right or wrong, then, I insist that we should try to treat our subjects from a basically artistic point of view, whether we teach engineering drawing, English composition, or anything else. Unless we give our students a sense of power and accomplishment, we have given them nothing. For man, if we read his long history aright, is by nature a creator, an artist, and in this he seems to differ from the rest of living things.

Bound, as we so often seem to be, by tradition and ancestral habit, there is always some one of us who refuses to do the same old things in the same old way, and who, moreover, is always on the watch for what other men will think of his accomplishment. Here lies the root of our "divine discontent," so alien to all other species, and here lies our supreme satisfaction —the one thing which makes conscious life really worth living. If we teachers can communicate this feeling to our students, we shall have given them something which they will never forget.

How, then, can we raise such a dull subject as English composition to the level of an art? Here I think we may take a hint from modern tendencies in teaching music and the graphic arts. We do not force a child to learn all the scales before he plays a tune or to master the technique of pencil and brush before he makes a picture. To be sure, this approach has its dangers, as witness the absurdities of "self-expression" in the form of pictures which only the artist can appreciate, of music which pleases nobody's ear but the composer's, and poems which communicate only that the poet has secrets he will not reveal.

It also engenders atrocious technique, or none at all. As my great-grandmother used to say: "Birds who won't sing can't"; and certainly some poets and painters write and paint the way they do because they can't do better. But basically the approach is right. Something to say must come before the saying of it, even though the thought will reach its full quality

only as it reaches its full expression. Technique is essential, of course, but it is only a means to an end, and can never be a satisfactory end in itself. Our human passion for analysis makes us try to separate form and substance, but in truth they can never really be separated. As Spenser once said:

For of the soul the body form doth take;
For soul is form, and doth the body make.

But in far too many English composition courses we try to make a sharp separation between form and soul, between technique and substance, even going so far as to give separate grades for each, impossible as that really is. How would you grade a Shakespeare sonnet, for instance? "When you look at me you see autumn, the end of a day, and a half-dead fire. But when I think of you, I feel like a bird." Worth a C, perhaps? Or would a D make him say something sensible next time? "Where yellow leaves, or none, or few do lie." Not a poetic word in the whole line, but give it a C because there are no misspellings? Yet who would really dare to correct one word of Shakespeare's here, or attempt to evaluate by a number the lovely curve of this sinking and soaring sonnet, with its over- and undertones of human meaning? "For soul *is* form, and doth the body make."

I do not mean that English teachers are unaware of this problem, or that nothing is being done about it. Now and again a textbook will try to break the pattern, and certainly individual instructors have often broken it—though not always with the approval of their colleagues. But at its peril any textbook omits the regulation "handbook" which will allow teachers to stay in the familiar rut, and there are always the accompanying books of exercises, complete with a teacher's manual. I have never myself seen any benefit derived from these exercises. A student can put in all the commas and ferret out the bad grammar and misspelled words without the slightest improvement in his own writing. And the teacher, if he has any real feeling for the English language, is bound to disagree with the "key." One learns to write by writing, not by picking flaws in someone else's isolated bad sentences.

So I believe that we should plunge our Freshman headlong into writing, leaving the handbook in the briefcase till we happen to need it for a particular point. We must remember that however bad our secondary schools are supposed to be, our Freshmen have spoken English for years and have done some reading and writing. We do *not* have to teach them the language, though we will certainly have to help them polish it a bit. They are *not* devoid of ideas, and, with the present high standards of admission in engineering colleges, they are not low in intelligence. To be sure, preceding English courses seem to have done their best to develop a dislike of "literature," but with only a few exceptions, our students are not uninterested in cultural matters, and they respond quickly to books which really have something to say to them.

Ability to Think

In one respect, however, they are woefully lacking; they have had little or no training in the processes of thought, and are therefore ill-equipped to develop their own ideas and arrange their available information so that they can communicate them to a

reader. And worst of all, they *know* they are poor writers (every teacher has apparently told them so), and they have no confidence in their own powers. Yet at the same time few of them realize that it takes at least as much effort to learn to write as it does to learn to draw or play the piano.

Here, then, is where we must start. First we should develop our students' confidence, and respect for their own ideas, leaving technique aside for the moment. Subjects for writing will have to be suggested, but everything possible must be done to make each man write only what he feels is worth writing. At the very beginning we must confess the artificiality of all school situations, but by imagination, if no other means are available, we must try to get them to write for a real audience.

For communication is usually very unsatisfactory unless you know who is at the other end of the wire. I often suggest slanting the writing toward the college paper, or toward the members of the particular class. And in the latter case, I make sure that a reasonable number of papers reaches that audience. Nonsense or empty verbiage soon yields to an unfavorable reaction from the class. With intelligent students like ours the *subjects* soon become very respectable indeed, especially if we insist that they must grow out of the man's own experience or information. For this reason I discourage "library" papers at the beginning. One does not learn to write by garbling what has been better written by others.

Inner Form and Order

The very first set of papers will reveal a lamentable ignorance of inner form. Apparently no one has taught our students that everything good in this world has a beginning, a middle, and an end. In these themes nothing is in the right place, paragraph indention is profuse, but paragraphs as logical units are almost nonexistent. Nothing is emphasized; everything is on one dead level. Incidentally, spelling is bad, sentences often askew, and punctuation unreasonable, but though I try to miss nothing with my red pencil, I refuse to be diverted by these correctable blemishes. What I must teach first is the principle of order, without which the world was once without form and void.

Obviously this is not something which can be accomplished by filling in blanks in exercise books. It must be done individually, as far as that can be done in the class-teaching of a subject which needs private instruction as much as do music and drawing. But it is thrilling to see a man's eyes open wide with surprise and pleasure as his own inchoate script comes to life with a simple transposition of sentences, a subordination of detail, or a slight change in wording.

At that moment we can perceive the dawning of a pride in language and a respect for the subtlety of an art of which the young writer has hitherto not been aware. In his next paper even the commas will begin to fall into the right places as he struggles with the problem of saying what he means. "For of the soul the body form doth take." I have seen that happen again and again, and so has every other sincere teacher.

From that point on, the man really begins to write as a conscious artist, however clumsy he may still be. He will thumb his dictionary, worry about his sentence structure, and ask how he can expand a vocabulary of

which he begins to feel the inadequacy. In short, he becomes fussy about technique because he now knows what he wants to use it for. He has learned the proper interrelation of substance and form.

Of course this thing does not happen quickly, but it does happen for almost all students if the proper atmosphere is faithfully maintained. Just this spring I experienced a heartwarming example of it.

In our college we fortunately have two years to work with our students' writing, and one section I happened to have taught for three of their four semesters. In the beginning, as Freshmen, they had shown all the possible faults. Now, as sophomores, they had just written their first technical reports—in each case on a subject which the man honestly wanted to deal with.

More than with any other class of mine I had spent the very minimum of time on external form, and my conscience was troubling me—as it often does. But every one of those reports was a pleasure to look at, and even more gratifying was the intelligent presentation of the material. To be sure, there were some slips in spelling, some hasty proofreading, and a few sentences that needed attention. But the general maturity was most impressive. Then for the next paper I suggested choosing subjects as far removed as possible from the technical matter we had been dealing with—*any* subject the writer felt worth presenting to the members of the class.

At ten o'clock, the night before the papers must be returned, I sat down to read them, bone-weary and brain-weary. One a.m. seemed my earliest possible bedtime. But something unexpected happened. The very first paper caught my attention; the second was better; every one of the nineteen had something to say—ranging through politics, history, philosophy, religion, personal affairs, education, music, and literature. Every one was alive; most of them were very well written, with "handbook" errors very scarce indeed. I finished them by midnight with the sensation of having found an unexpectedly good book.

Next morning I told the boys: "It's happened at last. For some reason you've suddenly learned to write. You will certainly write better some day, and if you don't keep on your toes you will often write worse. But I think you will never again turn out anything like the empty formless papers you wrote for me last year." Then, with inner trepidation, I assigned one more paper. For I had to know whether I was right.

I was. The final set was equally good. These men had actually learned to write. Then, for the first time, I was glad that I had been asked to deliver this paper, and then I really knew what I must say.

Broadened Horizons

It is particularly in engineering colleges that English teachers need to broaden their horizons. Trained as so many of us are in the "fine arts" aspect of language, we are sometimes repelled by the "useful arts" aspect. Yet beauty is not confined to the useless. Michelangelo's "Pieta" in St. Peter's is a lovely thing, but so is the George Washington Bridge. And I even maintain that the humble beer-can opener, as simple and graceful an implement as any artist could design for its purpose, has its own kind

of beauty too. Moreover, any fine business letter or technical report is far more beautiful than the literary monstrosities which put Geenwich Village intellectuals in a dither.

For what makes a work of art? Surely it is a worthy subject, whether an idea, an emotion, a sensation, or a mass of stubborn scientific data, which is so arranged and embodied in words or other media that the effect produced on the receiver is just what the artist intended. I do not mean, of course, that there is no difference is value among such achievements. The Shakespeare sonnet I have mentioned is infinitely more valuable than even the best Freshman theme, but the same principles apply to both. In each case the artist was trying to impose order upon disorder and to embody what he had to say in a form which would establish effective communication. And in each case, too, the creator had a right to feel pride in his creation.

If, in the short time I spend in intimate contact with my students' thought and their writing, I can make them feel even a small part of what I have been trying to say here, I believe I have justified English composition as a humanistic subject. For what we call the "humanities" is not a particular body of subject matter. It is an attitude of mind.

EDISON FOUNDATION CONFERENCE ON COOPERATIVE EDUCATION

A conference on "Cooperative Education and the Impending Educational Crisis" will be held in Dayton, Ohio, on May 23 and 24, by the Thomas Alva Edison Foundation. The objective of this conference is to highlight the educational values of a cooperative form of education.

Dr. Clarence H. Faust, President of the Fund for the Advancement of Education and Vice President, Ford Foundation, will address the meeting on "The Impending Economic Crisis in Higher Education," a problem presented by mounting enrollments. Dr. Ralph W. Tyler, Director of the Center for Advanced Study in the Behavioral Sciences, Palo Alto, California, will talk on "Educational Values of Cooperative Education." Dr. Samuel B. Gould, President of Antioch College, Yellow Springs, Ohio, will discuss "Cooperative Education as an Undergraduate Pattern."

Over 80 colleges and universities of the Mid West area, of which about 30 have some type of cooperative plan, have been asked by the Edison Foundation to send representatives to the conference. Also invited are representatives from over 100 leading firms who employ cooperative students.

THE EXPERIMENTAL ASPECT OF TEACHING PROCEDURES IN MACHINE DESIGN

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Presented at the 37th meeting of the Kansas-Nebraska Section of ASEE, held on the campus of the University of Wichita, October 26 and 27, 1956.

As a machine designer, an engineer must be a practical individual. In this area of engineering application, it is not his intent to discover new technical facts, but rather to use profitably those technical facts already discovered. Hence he must be familiar with these facts and have acquired more than a smattering of a great many fields, including such areas as engineering drawing, descriptive geometry, English, speech, kinematics, servo-mechanisms, statics, dynamics, strength of materials, materials of construction, manufacturing processes, metallurgy, and heat treatment. In fact, every subject involved in his engineering training must be called upon to supply information needed for good design.

A good designer must, therefore, have acquired and established a sound theoretical background and must use this as a foundation upon which to build a superstructure of practicality. He must be familiar with equipment, processes, and methods. He must have a working knowledge of costs and realize the advantages, limitations, tolerances, sizes, and capacities of equipment and machine processes.

I like to think of a designer as being someone special, more than a practioner of engineering "know-how." A good designer is more of a genius—a creator—an initiator of new and improved conceptions. In some ways we might think of him as being "eccentric," for he must operate and function differently. He must exhibit the characteristic of ingenuity in the application of all processes, and display a thorough knowledge of the principles underlying a wide range of materials and processes. He must acquire or be endowed with a lot of "know-why" as well as "know-how."

In designing a machine, he must also be something of a prophet—in that he must foresee and predict in advance every demand or emergency that the given machine may be required to meet. He must be able also to imagine, in fairly complete detail, all alternate plans that will meet the requirements both practically and economically. He must be able to determine which plan will offer the most for the money. Finally, he must be able to set down the final plan selected, complete and in detail, with sufficient clarity so that draftsmen can draw it and production staffs can make it. If his design cannot be built or if it will not function properly after being built, his time and effort is spent for naught and his company

has lost a great deal of money. Hence we see that a designer controls the choice of equipment, processes, kinds of machinery, and machine operations. He defines the form of the raw materials, the methods of manufacture, fabrication processes, costs and specifications. He therefore holds a key position in industry.

Educational Aspects

As educators, we are faced with the problem of training students in the judgment, the arts and skills of a designer, with all that implies. We are also faced with the responsibility of choosing the proper training methods, and this is not without a large element of the experimental. The same can be said of any design; as a matter of fact, all designs and all design training are basically experimental.

In machine design courses, the engineering student has an opportunity to view his training as a whole, and has the further opportunity to become familiar with the engineering problem approach. Here he first discovers that in some engineering subjects there is no real *right* answer, for there is no product that cannot be improved. Here, then, the student is challenged to produce his best, for the best is none too good.

Have we as engineering educators presented machine design this way, in the fullness of its challenge? Have we understood what sort of teaching procedure is necessary to train really successful designers?

Do the commonly used methods of presenting the subject of machine design give the student a true impression of his ability, or does it encourage him to follow some attractive line of engineering for years before discovering that he lacks the ability in this field to insure advancement? The latter is an injustice to the student wrought by the instructor.

Machine Design is the best course in the whole engineering curriculum to test or "prove" a student. It requires a panoramic review of all his prior training and challenges him to evaluate the degree of perfection which has been attained in all his previous course work. Gaps and points of weakness in his training take on realistic dimensions.

It is suggested that in all design there is the element of experiment and the student should be taught the importance of this element. The birth of any successful machine is based upon the application and performance of experiment. Men of foresight were dreamers—but dreamers who built wind-tunnels, put wheels and pistons and linkages and wings on their dreams, and by experiment made them practical. The Wright brothers put together a canvas-covered crate, and with the help of a strong gale at Kitty Hawk were able to get it airborne—but not without brilliant and sustained prior experiments.

Robert Fulton used a steam-powered paddle wheel to conquer the Mississippi River, but he had to work a lot of "bugs" out of it before he could even make the first attempt. Cyrus W. McCormick built a successful reaper, but not from his first design. And what of Peter Cooper's steam engine; Eli Whitney's cotton gin; Elias Howe's sewing machine; George Westinghouse's air brake; Ford's automobile, and Oppenheimer's atomic bomb?

Even from the time when man pried up the first heavy stone with the limb of a tree to the time when man must design the complex ele-

ments and systems of a B-52 bomber –from the time man cast the first stone to the explosion of the last hydrogen bomb–design and experiment have gone hand in hand down the road of progress. One would be lost without the other–and neither could survive alone.

All successful design requires the help of experiment, and experiment requires the help of design. Even the best designer of machines is likely to overlook some minor but important function of the machine he designs. This oversight always calls for the experimental aspect of design, and testing is the only way of proving the product.

Again, it seems that students should be taught that design has two different aspects:

(1.) The analysis of machine elements–machines already built.

(2.) The synthesis of machine elements–machines to be built.

The former applies to the checking of a designed machine, determining whether or not the elements are sized properly, whether or not the material was properly selected, and whether or not the individual parts would function under the conditions specified. This type of training on the part of the student in design is needful and certainly this is the place to *begin* his training, but it should not constitute the goal.

Up to this point, the student is not trained to design machines. And because the training so often ends here, can we attribute to this the dependence of industry upon men who come up through the shop ranks, loaded with experience but not college-trained, to be responsible for directing design.

Industry needs to have machine parts analyzed–parts which have failed in service–but the greater concern is to build new assemblies from component parts. Men trained in *synthetic* design are needed to accomplish this. Industry isn't troubled nearly so much with the need for analysis of machines already built and in service, as for the creation of novel and imaginative fresh types of machines. To accomplish this aspect of design, students must have their minds probed and their creative abilities aroused.

Teachers who can stir up the student's imagination and get him to think creatively are good teachers. H. P. Hammond defined good teaching in this way: "Good teaching is the development of the student's ability to think-for-himself." If a student can be induced to think-for-himself, to the best of his capabilities, he will make a contribution of some kind.

Students should be taught that there are many approaches to the solution of any design problem for which they have been assigned the responsibility. That there are methods for making each of these approaches do the job. A student's problem in design is not solved without consideration being given to every possible solution. He should be discouraged from the mistake of preparing but a single design and attempting to defend that solution against all suggested alternates.

Good practice would be to have students present their designs orally to the class or before specialists and encourage discussion to bring out the shortcomings and improvements. In this process, the student should be taught the art of defending his ideas and at the same time learn to accept or compromise judiciously and read-

ily when valid criticism is made. To make a proper defense the student must know his design.

It is common knowledge that the more thoroughly one understands his design problem, the more new combinations will be revealed for its solution. The more the problem is analyzed, the more possible approaches and solution methods are revealed and the better will be the final resultant solution. As this process continues, additional ideas will appear, until finally something superior will begin to congeal, respresenting the best possible solution. Such procedure can be developed by the student and must be, if he is to serve humanity to the best of his capacity.

Let us not conclude this subject without a word of warning. We live in a time of rapid scientific progress—but progress has a tendency to act as a sedative, something quite in evidence in the teaching profession. In periods of rapid progress, individuals have a tendency to become satisfied with the "*status quo*" and become perfectly willing to continue on without further change or adjustment.

In our society, of recent years, we have experienced so much in the way of advance that we have a tendency to become complacent and contented. This condition is the enemy of good design. Good design thrives upon dissatisfaction, change, new processes, new products, improvements in quality, new means of producing quantity, and ways of improving appearance. It is only by being conscious of the constant need for change that the student will be at his best in supplying new ideas. When he is motivated by a fierce determination to succeed with the change, he will begin to investigate, to experiment, and to produce. He must create within himself a challenge and determination to be victorious over that challenge before he will succeed.

There must be a strong desire to succeed; this is essential in the useful creative process of synthesizing design. Can a teacher arouse this personal challenge in his students? Can a teacher instill a high degree of initiative and perseverance? If he can, success will be more readily and more quickly realized.

In conclusion, may we suggest that courses in machine design offer one of the greatest challenges of any in our engineering curriculum, both for the instructor and the student. For while the particular viewpoints of class and teacher may differ, the objectives are the same.

COLORADO STATE UNIVERSITY

Effective May 1, 1957, Colorado Agricultural and Mechanical College, Fort Collins, will be called Colorado State University. Concurrent with the change in name, the undergraduate schools at the University are redesignated the College of Agriculture, Engineering, Forestry and Range Management, Home Economics, Science and Arts, and Veterinary Medicine.

GRAPHIC SCIENCE

Analysis—Synthesis—Communication

Sponsored by the Engineering Drawing Division
Editor: J. N. Arnold, Purdue University

BASIC PRINCIPLES FIRST

H. C. SPENCER

Director, Technical Drawing Department
Illinois Institute of Technology, Chicago

Presented at Fifth Engineering Drawing Summer School, Iowa State College, Ames, Iowa, June 20–29, 1956

You will recall that two different types of curricula were suggested in the preliminary Grinter Report of 1953—the *professional-general* and the *professional-scientific.* This was "bifurcation." It was stated that four years would be sufficient for the professional-general course, but more time would probably be required for the professional-scientific.

A great howl went up. Bifurcation would mean that professional-scientific curricula would be "first class" and professional-general would be "second class." The majority evidently felt fairly certain they would wind up in the second class, and they did not like the idea. Nevertheless, we have had right along some institutions whose curricula were directed toward the more scientific objectives, and many more which were and still are dedicated primarily to the *art* of engineering—that is, to the development of the every-day engineer who is not a research worker primarily or engaged in creative design. In other words, we have had bifurcation right along, and still do.

Nevertheless, the idea of bifurcation was generally disapproved, and it was dropped by the Grinter Committee in its revised report. Dean R. L. Sweigert said, in a JOURNAL article, that "while the suggestion of bifurcation was thoroughly frowned upon, nevertheless the idea continually rears its head." And well it might! In another paper, Dean Hawkins attempted a classification of engineers, and concluded that "for every 100 engineering graduates only a few will be in the 'engineer-scientist' and 'creative-design' classification."

He says also, "we now find ourselves in an apparent dilemma" in attempting to provide education for all sorts of engineers, not to mention those who will never enter engineering at all. In other words, how are we to train the super-scientific engineer and the everyday applied engineer in the same curriculum? He finally recommends that we train "professional engineers," by which he means the more scientific type.

"Science-Oriented" Curricula

Anyway, the Grinter Committee's solution was the "scientifically-oriented" curriculum, which is apparently in line with Dean Hawkins'

philosophy, emphasizing basic sciences, engineering sciences, and humanistic-social studies. Questions that only time will resolve are whether all engineering students should go through this type of curriculum, or whether industry will be satisfied with the resulting product.

It all depends upon how these things are worked out in institutions across the country, and upon the work of ECPD. There is no question in my mind but that we are and should be headed toward the more scientific curricula, but it also seems inevitable that we must continue to train, for a long time to come, large numbers of engineers who will function in the areas of management, sales, operations, maintenance, and so on.

Under the circumstances, it would appear that in practice the curricula will not be as scientific as some would like, nor directed as much toward the "art of engineering" as others would like. The net result will be that most schools will, in order to meet ECPD requirements based upon the Grinter Report, "beef up" their curricula in terms of basic science, engineering science, and in many cases, humanistic and social studies.

At Knoxville I complained that engineering drawing was not classified as an engineering science by the Grinter Committee. Then, in the November JOURNAL of the ASEE, Mathew McNeary presented a very strong argument for this same idea. Nevertheless, we find ourselves classified only as a part of the "Non-Departmental Engineering Courses," along with the professional engineering courses.

This means that none of our time can come from that allocated to (1) humanistic-social studies, (2) mathematics and basic sciences, (3) engineering sciences, or (4) certain options and electives. It must come from the area of engineering courses —which means that we are in the biggest squeeze ever, because engineering courses will have to be cut to the bone to allow the time allotted to the areas I have just mentioned. For example, an electrical engineering department which has already lost valuable professional courses in order to make more room for humanistic-social studies, mathematics, and science will be sorely tempted to see if it cannot get along on less drawing.

More Time Needed

Personally, I feel that it is impossible, with these new restrictions, to provide in four years the well-rounded training our young engineers should have. We are already eliminating some valuable subjects, pushing some up into graduate work, and attempting to push others down into the high schools. We are literally bursting at the seams. The 5-year curriculum is an inevitable necessity.

I have dwelt at length on these general conditions because we must consider our problems in terms of this background. As boresome and distasteful as it may be to repeat, I am compelled to say that *time* is our basic problem. The pattern over the country is fast resolving itself into one term of drawing and one term of descriptive geometry, or a combination of the two, and in some cases the total available time is even less. In one of our great institutions, it is actually possible for a student to graduate without any college drawing whatsoever.

Now, the Grinter Report gives little space to drawing, but what it does say is pretty clear. It is incumbent

upon us to examine these statements carefully to see if we are measuring up, and to see if we can do what we are required to do in the allotted time.

Standards for Graphics

"Graphical expression is both a form of communication and a means for analysis and synthesis," which is to say it is a graphic language and a graphical tool for solving problems. I cannot speak for anyone else, but I feel pretty sure that at Illinois Tech we are meeting these objectives with courses that are as rigorous as the other courses taken by our students at the same time.

The Report goes on to say of graphics that "Its value as a skill alone does not justify its inclusion in a curriculum." This wounds me deeply. As long as I can remember—and that's a long time—I have heard over and over again "We are not training our students to be draftsmen." The very mention of the words "skill" or "lettering" makes the average drawing teacher wince with pain.

Our inferiority complex has become so enormous that even the word "drawing" sounds too low-level. We've been casting about for anything and everything that seems to be more intellectual. What we should be doing is making sure that we are adequately covering what we should and that it is carried out at the college level.

Note that the Report uses the term "skill alone," implying unmistakably that skill is not to be completely overlooked or be apologized for. A reasonable amount of skill—and nobody asks for more—is necessary to implement and develop fully the theoretical principles. After all, drawing is a graphical tool and should be used with as much precision as possible. Yes, we can still consider the development of habits of neatness, accuracy, and a reasonable degree of skill as worthy objectives, and there is nothing in the Grinter Report that suggests the contrary.

The Report goes on to affirm that "the emphasis should be on spatial visualization." Well, this is certainly our strong point. If any of our courses are weak in this respect, it means that the general level of such courses is not high enough—too much pencil pushing and not enough headwork. So, again, the answer is really to get into the problems of projection. Our class problems should challenge the best of our students.

The Report continues, noting that we should provide "experience in creative thinking," and the ability to convey ideas, especially by freehand sketching—which is "the normal mode of expression in the initial stages of creative work."

Naturally, not only in drawing, but in all courses, original or creative thinking should be encouraged as much as possible. We should encourage the student to ask "why"—not simply to follow the book. We should present problems that require some thought on the part of the student, and whenever we can, arrange them so that he has to devise his own method of attack. Whenever possible, we should get away from rote problems with only one procedure and one answer. And they should be *problems,* not exercises.

Dimensional Thinking

Nevertheless, let's keep our feet on the ground. The college student, particularly the freshman, cannot be expected to be creative in the strict sense. His hands are full acquiring

the tools with which he will work after graduation. There is some validity to the argument that to be creative, one has to have at hand the tools of knowledge, and that real creativity can occur only after these tools have been acquired and assimilated.

Probably the best contribution we can make toward creativeness is to develop the student's ability to think in three dimensions and to express himself graphically in an effective manner. The real pay-off comes when your former student comes back and shows you some original design that he created, using the engineering and science principles he has learned, and warmly shakes your hand in appreciation for what he learned from you in freshman drawing.

The Report emphasizes the value of sketching as a means of conveying ideas in creative work. Of course, freehand sketching is even more of a skill than is mechanical drawing—so this is another affirmation that the development of skill still has a place in our work. Also, note the words "conveying ideas," indicating again the importance of drawing as a means of engineering communication.

We cannot, in the brief time available, hope to develop real skill in freehand sketching any more than we can in mechanical drawing. If we did we would be open again to the old charge that we are interested in "skill alone." Many of us are already teaching considerable freehand sketching—probably as much as possible in the time available. Others undoubtedly are doing little along this line, and should do more.

Actually, the students need an entire course in freehand sketching to develop appreciable facility. But this is **not** in the cards. Freehand sketching must be taught in our present courses. But bear in mind that whenever freehand sketching is used, mechanical drawing is not used—which means, of necessity, a considerable de-emphasis of mechanical drawing. It would appear that if freehand sketching is introduced to any worthwhile degree, there can be no danger of too much emphasis on "fine draftsmanship."

Freehand Sketching

I definitely favor increased emphasis on freehand sketching. The best way to do this is to use freehand sketching whenever it is suitable as a medium for learning the theory, and to use mechanical drawing where it is most practical. In other words, use sketching where it comes naturally, just as an engineer would in pratice. It should be used to develop ideas, plans of attack, tentative methods of solution, before actually getting down to exact scale. It can also be used in the early stages of learning theory in class.

The beginning phases of nearly every topic, as multi-view drawings, sectioning, auxiliary views, pictorial drawing, and even dimensioning, can be just as easily motivated through freehand sketching. These early sketches can be made on cross-section paper. Later sketches can be required on plain paper. Sketching can be used to advantage at intervals throughout the course, even in advanced phases. If we use freehand sketching at every place where this technique can be advantageously employed from a teaching standpoint—that is, where it is most useful in implementing the learning factors—we can easily comply with the recommendations of the Grinter Committee.

The main requirement is a teacher who is himself a competent sketcher —especially on the blackboard where example teaches more than precept. Those of us who are not properly prepared should start doing so at once. Practice sketching wherever possible—at the blackboard, at the students' desks, in your lecture notes. If possible, take a course in freehand drawing from the local art teacher, or from the art department in your own school.

Graphic Communication

The Report goes on to say, "Though the engineer may only supervise the preparation of the drawings required to execute his designs, he can hardly be expected to do this effectively unless he himself is thoroughly familiar with graphical communication." Note the term "communication." It is used twice in the brief paragraph in the Report, in addition to the phrase "convey ideas." Also, at the beginning of the entire report there is a summary of conclusions. We should be extremely pleased to see our objectives recognized in this overall statement of the aims of engineering education.

Item No. 6 is: "An insistence on the development of a high level of performance in oral, written, and *graphical communication* of ideas." Now, it is pretty obvious that the Committee does not look down their respective noses at the idea of "communication." You will also note the words "high level of performance" in this graphical communication of ideas. In short, while the Committee has made it perfectly plain that "skill alone" should not be the objective, the development of reasonable skill is necessary; and they have made it amply clear that our main overall objective should be to teach the graphic language as a means of communication of ideas. Now it is obvious, I think, that whatever we do, we should see to it that this main objective is realized.

Graphics

Nowhere in the Report is there any mention of engineering graphics, nomography, graphical computation, the slide rule, or similar topics. I am quite sure that the Committee did not omit these because of ignorance, or because they thought them unimportant. But such things take time, and the Committee knows, if we do not, that there simply isn't enough time. We have been talking about these things for years, and many fine papers have been presented before the Division and in our JOURNAL. We used to hear advocacy of "advanced graphics," or "graduate work in graphics," all of which I heartily endorse. But now some are advocating substituting these topics for basic material in beginning courses and I object to this.

If, in some schools, time is really available for the basic fundamentals, plus some of these desirable subjects, well and good. But, in the present circumstances—in the present general squeeze—I doubt if there is enough time in most institutions to include more than a smattering of these topics. And since it must be a smattering at best, I wonder if it is worth the loss of time in projection fundamentals. We have complained for years that we didn't have enough time, and with good reason. Now, when the time available is reduced almost to the point of absurdity, it simply does not make sense to add more material.

Those topics collectively known as "graphics" are important, and we should do everything we can to ad-

vance them. But it isn't just a question of convincing ourselves; we've got to sell the idea to the curriculum-makers. If our engineering colleagues and administrators really want the students to have a required course, or even an elective course along these lines, all they have to do is say so, and *provide the time to do it.*

Or, if we are enterprising, we can suggest one or more elective courses, and get approval to offer them. I am glad to say that at Illinois Tech we do have courses in advanced descriptive geometry, engineering graphics, and nomography, to name a few. I know of a number of other schools which offer courses in these and like subjects, and I hope there will soon be more.

The chief criticism that should be made is that some of our beginning courses are not being taught at the college level. It does no good to take a course which is already being taught at the high school level and then water it down further by the introduction of mathematical topics in order to give it an aura of respectability. Nor should we take a course which is strong in covering the basic principles, and by wholesale deletions leave insufficient time to cover these fundamentals adequately.

Even in communities where a large percentage of students have had high school drawing, many of them appear to have learned little *by college standards.* How can we expect a student at the age of 13 or 14 in high school to learn much that can be applied to a college-level course? However, a large percentage of our students come to us without any high school drawing anyway. Except in a few isolated cases, we cannot push down into the high schools any of the content of our college courses.

Shortening of Topics

If we cannot find additional time by depending upon the high schools to cover a part of our work, then such time would have to come from our present topics. Either whole topics will have to be omitted, or some will have to be shortened. Can this be done? Let's assume that you now cover the basic fundamentals well, the course is properly taught at the college level, and that you are really using the limited time you have, without waste. To find time for extra topics, you decide to spend less time on some basic topics.

This means that you simply will not be able to develop each topic as far as you have before. You cannot cut out any of the beginning problems, for it is assumed that you already start the students with problems as difficult as they can handle. The only alternative is to cut off the more difficult assignments at the end of each unit, and your students will then miss the problems that are most thought-provoking and beneficial. This, I believe, is just what should not be done.

Of course, if you are fortunate in having available all the time you need to cover the basic principles, plus some extra, then by all means add new and stimulating material. There is an almost unlimited number of highly useful topics from which to choose. You should make good use of all the time you have. If, on the other hand, you are already short on time, it is difficult to see how you can add such topics without damaging your program.

To Sum Up

In summary, our long-accepted objective of teaching the graphic language as a means of developing and communicating technical ideas has

been unequivocally affirmed by the Grinter Report. We have been reminded, though it was not necessary, that skill alone should not be our objective. We have been urged, along with teachers in all other subject areas, to give more attention to the development of creativeness.

This simply means making our work as thought-provoking as possible, with encouragement for the student to do some thinking on his own. Freehand sketching, though primarily a skill, has been pushed to the fore, and we should give more time to it. Throughout the Report, it is made amply clear that in all courses, including our own, the basic principles should come first.

JOINT RWI-SECONDARY SCHOOL COMMITTEE & SELECTION & GUIDANCE COMMITTEE SESSION

On Monday, June 17 at 2:00 P.M. at the Annual Meeting, the Relations With Industry Division, the Secondary Schools Committee, and the Selection and Guidance Committee are holding a joint session on the very important topic of the long-range improvement in science teaching for secondary schools. The viewpoint of industry, the universities, and the high schools will be presented. This should be of considerable interest to many members of ASEE.

X-RAY DIFFRACTION DATA OFFERED AT SPECIAL PRICES

The X-Ray Diffraction Data Card File, published by the American Society for Testing Materials, is now being offered to colleges and universities at 80% discount from list prices. The discount is offered only on the basis that the card file will be used for classroom instruction. A certification to this effect will be required for the special discount.

ASTM acts as business agent for the Joint Committee on Chemical Analysis by Powder Diffraction Methods, offering techniques for the identification of approximately 5000 crystalline materials by the Hanawalt Method. The data have been collected from industry, literature, and laboratories, and are available on plain 3-by-5-inch cards, 4-by-6-inch Keysort cards, and standard IBM cards. Literature and schedule of prices of the File will be furnished on request by the X-Ray Department, ASTM, 1916 Race Street, Philadelphia 3, Pa.

. . . . . YET-ITUDES

VIEWS AND NEWS CONTRIBUTED BY

The Young Engineering Teachers

T. A. BOYLE, Chairman
Whitmore Lake, Michigan

ROBERT D. LARUE, Editor
Colorado State University

THE TEACHING OF "ENGINEERING PHILOSOPHY"

ROBERT J. McFARLIN

Structural Design Engineer
Vogt, Ivers, Seaman, and Associates
Cincinnati, Ohio

We in engineering have a heritage and a culture which we can claim as our own. The introduction of these concepts into an engineering curriculum will certainly be of considerable value to the young engineer and will be in line with the current trend toward inclusion of more topics from the humanistic-social field.

An "Engineering Philosophy" program as proposed here would be continuous over the first two years of college, and would include one credit-hour per semester, or a total of four. Many engineering colleges include some of this work in present curricula, particularly in the freshman year.

The program will begin with a semester's work very similar to what is called Engineering Orientation, and which is required with no credit in many schools. There will be a textbook (surprisingly enough, there are several very good ones on this subject), a final examination, and an hour's credit, all of which will mean better attendance and attention than in the present sessions.

It is intended to describe each branch of engineering as is done now, and to add a thorough treatment of the history of engineering. The writer is in general agreement with those educators who consider history to have a great value for all. Engineering history is a rich and interesting field, but much of it is hidden in old books and papers or has never been recorded at all. Therefore, any instruction in this subject requires much research, but the results will be well worth the effort.

The second half of the freshman year would be spent on "The Engineering Method," which is a more dignified name for what is now called "Engineering Problems," "Slide Rule," or various other terms. This is a course in which the students meet for a single two or three-hour session per week and are instructed in the use of the slide rule, analytical method, and in the neat, orderly presentation of problems.

The writer believes that a majority of engineering colleges have such a course. He recommends for them only the better name and inclusion in the "Engineering Philosophy" series as a subject that is peculiarly ours.

Introduced in the first semester of the sophomore year is a course in "Professional Ethics," covering certain other concepts along with the primary one, ethics. It is felt that this is the most significant item to be offered in the program. It is the writer's idea that if any material is to be shortened or omitted it shall not be this material and that the presentation may extend as far into the second semester as necessary.

It is desired to develop also a concept of "Professional Ethics" which are far different from "Ethics" in the general sense of the term. Professional Ethics represents something more than honesty, justice, and morality. These are the traits included in "Ethics" and they apply to all decent people.

The first step, then, is to define our profession and to give the student a very clear concept of this definition. Basically, it should be shown that a profession is a legal entity, in general rendering to the public a service that must be accepted on faith. Society, by law, issues licenses allowing individuals to practice the professions. Issuance of the license may be refused or revoked, thus forbidding individuals from practicing. In general, when the public has a reasonable knowledge of the work, and can judge the value of the service, state licensing is not required, and, in the legal sense, a profession does not exist.

At this point in the course there should be a careful study of the local registration requirements, the Engineer-in-Training category, and the fact that a bachelor's degree does not make an "Engineer." Such status comes later, as the result of experience and passing certain examinations. The use of the word "Engineer" should gradually come to mean "Professional Engineer."

Having developed the idea of a profession, the next step is to show how the professional has extra responsibilities which the layman does not have. The student can easily realize that a salesman or tradesman can be "honest, just, and moral," and still be less than spotless in his business dealings, simply because he places personal gain before ethics.

A professional must never do this. Public service must come before personal gain (exactly the opposite of business), and, therefore, the ethics of the professional must be on a different and higher plane than those of the non-professional. The writer has presented students with this concept of service before gain and, far from being distasteful, it seems to inspire most of them.

The question of engineering unions must next be dealt with. The writer is, in general, reluctant to impose his opinions of controversial issues upon his classes. However, there seems to be near-unity among the leaders of the profession in the judgment that unions and professions are incompatible. The union agitation appears to come largely from technicians, and also from the younger graduate engineers, who feel that as professionals their financial progress is too slow. These young men move away from radical ideas as they grow older and find that they do, in fact, climb the ladder of success eventually.

Union agitation, however, is one of the very strong influences exerted on new graduates, and a great service would be done them if they were made acquainted with the issue while they were still in school. The writer feels that it is not difficult by enlight-

ened discussion to turn our students away from unions and toward professionalism, but we must be willing to face the issue. Assuming that the "professionalism" idea has been driven home, a clear explanation of the facts is all that is needed.

In this semester's work the student should also be introduced to the various professional societies. As much use as possible should be made of the literature of those societies; e.g., the "Canons of Ethics for Engineers" of the National Society of Professional Engineers. It is important for the students to realize that the course includes views of the leaders of the profession.

In what time remains, the study will be of logic. Unlike its sister subject of ethics, logic does not have special significance for engineers except that we perhaps use more than our share of orderly and efficient thought processes. It is believed that some time devoted to this subject will make the functioning of our minds more efficient than it is.

In conclusion, the writer feels that the programs presented here would be a useful step toward developing the professional engineer and away from developing the technician, which is too often our product. We need the skill of efficient calculations, the breadth that comes from a knowledge of all the branches of engineering and their history, the high ideals and inner strength derived from Professional Ethics, and the clear head that comes from a knowledge of logic.

The program as proposed uses so little time that its inclusion in all curricula should be possible. Finally, much of the total significance is derived from the fact of *continuity*, and it is felt that this *cumulative* importance is much greater than would be the case for the individual units considered separately.

ANNUAL MEETING TRANSPORTATION

Charter Air Service: Single and small multi-engine charter planes and an air-taxi service are available. If interested, contact Chartair, Tompkins County Airport, phone 9603, or Peter's Air Charter Service, Municipal Airport, phone 8625, both in Ithaca.

Rental Cars: Contact Hertz Rent-A-Car System, 302 West Seneca Street in Downtown Ithaca, phone 4-3400. For late arrivers in Syracuse who wish to go to Ithaca after the last bus has left, a Hertz car can be rented in Syracuse and left with the Hertz office in Ithaca. There is an inter-city charge for having the car returned to Syracuse but the rate depends upon how much use is made of the car. If a Hertz car were picked up in Syracuse, driven to Ithaca, and left without further use, the cost would be about $14.00, plus an inter-city return fee of $7.00. However, if the total bill for use of the car were at least $25.00, there would be no inter-city return fee charged.

NEW MEMBERS OF THE ASEE

As of February 25, 1957

ANDREWS, ROBERT E., Assistant Professor of Mechanical Engineering, Bradley University, Peoria, Ill. M. G. Abegg, W. E. Short.

ARNELL, WALTER J., Instructor in Engineering, University of Southern California, Los Angeles. K. C. Reynolds, H. P. Nielsen.

BAILIN, LOUIS L., Professor of Electrical Engineering, University of Southern, California, Los Angeles. G. T. Harness, R. E. Vivian.

BATTISTA, VITO P., Director, Institute of Design and Construction, 311 Bridge Street, Brooklyn, N. Y. J. I. Miller, H. W. Shaw.

BENDER, DONALD L., Instructor in Civil Engineering, Washington State College, Pullman. G. H. Dunstan, R. H. Nelson.

BENDER, PHILLIP R., Assistant Professor of Mathematics, Milwaukee School of Engineering, Milwaukee, Wis. D. G. Haertel, F. J. Lofy.

BILANSKI, WALTER K., Associate Professor of Engineering Science, Ontario Agricultural College, Guelph Ontario, Canada. C. G. E. Downing, G. F. Tracy.

Divisional Interests: Agricultural Engineering, Mechanics and Material

CARLSON, H. MAURICE, Associate Professor of Mechanical Engineering, University of Louisville, Louisville, Ky. H. H. Fenwick, R. C. Ernst.

CHIARULLI, PETER, Professor and Chairman of Mechanics, Illinois Institute of Technology, Chicago. F. D. Carvin, C. E. Deakins.

CLEARY, JOHN J., Assistant Professor of Mechanical Engineering, North Carolina State College, Raleigh. R. M. Pinkerton, J. F. Lee.

Divisional Interests: Aeronautics and Aeronautical Engineering, Mechanical Engineering.

COUCH, J. H., Associate Professor of Industrial Engineering, Clemson College, Clemson, S. C. J. E. Shigley, J. C. Cook, Jr.

CROTHERS, MILTON H., Assistant Professor of Electrical Engineering, University of Illinois, Urbana. H. N. Hayward, H. W. Horn.

Divisional Interest: Electrical Engineering.

CURRY, THOMAS H., Assistant Professor of Chemical Engineering, Ohio University, Athens. E. J. Taylor, P. H. Black.

DALIA, FRANK J., Assistant Professor of Civil Engineering, Tulane University New Orleans, La. F. H. Fox, W. E. Blessey.

DEUTSCH, MAURICE N., Instructor in Engineering, Valley Junior College, Van Nuys, Calif. Bonham Campbell, J. M. English.

DURDEN, FRANCES C., Assistant Professor of English, Tuskegee Institute, Tuskegee, Ala. J. D. Davis, Jr., W. L. Collins.

Divisional Interests: English, Librarians, Graphic Art.

EADIE, GEORGE R., Assistant Professor of Mining Engineering, University of Illinois, Urbana. T. A. Read, B. G. Ricketts.

Divisional Interest: Mineral Technology.

ENGLISH, MARVIN L., Associate Professor of Mechanical Engineering, University of Cincinnati, Cincinnati 21, Ohio. J. W. Bunting, O. Elnan.

Divisional Interest: Mechanical Engineering.

EYER, PATRICIA H., Instructor in Mathematics and Science, Tri-State College, Angola, Ind. Alice Parrott, G. S. Rowley.

HART, MITCHELL T., Supervisor, Engineering Training, Autonetics—A Division of North American Aviation, Inc., Fullerton, Calif. L. Cromwell, H. Storch.

HARTLEY, HERBERT W., Assistant Director, Northrop Aeronautical Institute, Inglewood, Calif. J. L. McKinley, C. T. Reid.

HARTMAN, DAVID P., Research Assistant, Electrical Engineering, University of Wisconsin, Madison. H. A. Peterson, J. J. Skiles.

HOLMEN, HOLGER E., Instructor in Industrial Arts, Waldorf College, Forest City, Iowa. J. S. Rising, M. W. Almfeldt.

HOPWOOD, JOHN F. X., Instructor in Civil Engineering, Villanova University, Villanova, Pa. J. S. Morehouse, J. J. Gallen.

HUDSON, WILLIAM G., Assistant Professor of Mechanical Engineering, Clemson College, Clemson, S. C. J. C. Cook, Jr., A. D. Lewis.

JENSEN, RALPH C., Officer in Charge, Civil Engineer Corps Officers School, Naval Construction Battalion Center, Port Hueneme, Calif. J. M. Coke, F. R. Campbell.
Divisional Interest: Engineering Management as applied to Civil Engineer Corps, United States Navy.

JEVARJIAN, ANTHONY, Training Specialist, Sperry Gyroscope Company, Sperry Rand Corporation, Great Neck, Long Island, N. Y. W. L. Everitt, W. L. Collins.

KELLEY, HARLEY H., Associate Professor of Engineering, Pennsylvania State College, University Park. V. V. Detwiler, C. K. Arnold.

KNOBLOCK, EDWARD W., Instructor, University of Wisconsin, Milwaukee. H. W. Knutson, W. M. Christman, Jr.

KREER, JOHN B., Assistant Professor of Electrical Engineering, University of Illinois, Urbana. A. D. Bailey, M. E. Van Valkenburg.
Divisional Interest: Electrical Engineering.

LEE, J. HILDRED A., Assistant Professor of Engineering Science, Ontario Agricultural College, Guelph Ontario, Canada. C. G. E. Downing, D. F. Tracy.
Divisional Interests: Agricultural Engineering, Mechanical Engineering.

LUCKY, GEORGE W., Assistant Professor of Electrical Engineering, Oklahoma A. & M. College, Stillwater. A. Naeter, T. B. Thompson.
Divisional Interests: Electrical Engineering, Mathematics.

LUTZ, PAUL C., Instructor in Engineering Drawing, University of Louisville, Louisville, Ky. H. H. Fenwick, R. C. Ernst.

MCCASLIN, JOHN G., Assistant Professor of Physics, Montana School of Mines, Butte. W. C. Laity, J. H. Albertson.

MERRY, BENNETT E., JR., Instructor in Industrial Electricity, Wentworth Institute, Boston, Mass. H. R. Beatty, F. H. Linton.

MEYER, FLOYD H., Instructor in Engineering Drawing, State University of Iowa, Iowa City. J. M. Russ, M. L. Betterley.

MOENKHAUS, ARTHUR E., Instructor in Mechanical Engineering, Michigan State University, East Lansing. W. P. Smith, J. D. Ryder.

MORGAN, WILLIAM W., Assistant Professor of Industrial Management, Alabama Polytechnic Institute, Auburn. B. K. Collins, E. I. Brown.

NEWTON, ALFRED F., Instructor in Industrial Engineering, Clemson A. & M. College, Clemson, S. C. J. C. Cook, Jr., C. E. Littlejohn.

OLVER, ELWOOD F., Associate Professor of Agricultural Engineering, Pennsylvania State University, University Park. E. A. Myers, J. E. Nicholas.

PERRY, BYRNE, Research Assistant, Department of Civil Engineering, Stanford University, Stanford, Calif. R. K. Linsley, J. B. Franzini.

RAIMONDI, THOMAS V., Director, State Technical Institute, Hartford, Conn. J. T. Nerden, W. L. Collins.

RICH, NATHAN H., Associate Professor of Agricultural Engineering, University of Maine, Orono. R. B. Rhoads, B. L. Bondurant.

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SKINNER, HALVER M., Associate Professor of Agricultural Engineering, Montana State College, Bozeman. C. G. E. Downing, W. L. Collins.
Divisional Interests: Agricultural Engineering, Shop and Mechanic Arts.

THOMPSON, DAVID G., Instructor in Electrical Engineering, University of Maryland, College Park. E. H. Small, L. J. Hodgins.

WAKEMAN, TRUMAN J., Professor of Farm Mechanics Education, Virginia Polytechnic Institute, Christiansburg. C. G. E. Downing, W. L. Collins.
Divisional Interest: Farm Mechanics Education in Agricultural Engineering.

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As of March 6

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SHANNON, SAM S., Publisher's Representative, International Textbook Company, San Francisco, Calif. R. A. Nottenburg, K. R. Gromlich.

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STASHAK, GERALD J., Publisher's Representative, International Textbook Company, Scranton, Pa. R. A. Nottenburg, K. R. Gromlich.

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WOIDZIK, ALBERT T., Assistant Professor of Fabrics, Lowell Technological Institute, Lowell, Mass. M. E. Gelinas, J. A. Irvine.

WYNN, ROBERT S., Professor of Electrical Engineering, Louisiana Polytechnic Institute, Ruston. B. T. Bogard, A. C. Thigpen.

YOUNG, FREDERICK J., Assistant Professor of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. E. M. Williams, E. R. Schatz.

ZABCIK, CALVIN L., Instructor in Engineering Drawing, Arlington State College, Arlington, Tex. J. S. Hopper, G. E. Smith.

ZEMANIAN, ARMEN H., Assistant Professor of Electrical Engineering, New York University, New York. Sheldon S. L. Chang, Paul Chirlian.

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634 new members this year

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Convair, A Division of General Dynamics Corporation, Fort Worth Division, Fort Worth, Texas. *Representative:* H. A. Bodley, Engineer. 1957.

General Dynamics Corporation, 445 Park Avenue, New York, New York. *Representative:* C. M. Barlow. 1957.

Radio Corporation of America, Front and Cooper Streets, Camden, New Jersey. *Representative:* Robert Haklisch, Manager. 1956.

A. O. Smith Corporation, Milwaukee, Wisconsin. *Representative:* John E. Conway, Director of Education & Training. 1956.

TEACHING POSITIONS AVAILABLE

GENERAL ENGINEERING INstructor and Assistant openings. B.S. engineering degree and good academic record required. Teaching or industrial experience desirable. Graduate study encouraged. Write to R. P. Hoelscher, 116 Transportation, University of Illinois, Urbana.

CIVIL ENGINEERING OR ENGIneering Mechanics Associate and Assistant Professors and Instructors needed. M.S. degree desirable, but instructors working toward advanced degree will be considered. Salaries for nine months academic year, paid in ten installments, based upon experience and education. Start September, 1957. Applications for a position as Instructor in Engineering Drawing, Descriptive Geometry, and Surveying will also be considered. Write to Earl D. Dake, South Dakota School of Mines and Technology, Rapid City.

CIVIL, ELECTRICAL, AND MEchanical Engineering staff openings. Salary depends upon qualifications. Apply to the Dean of Engineering, Villanova University, Villanova, Pennsylvania.

CHEMICAL ENGINEERING FACulty member needed. Rank and salary dependent upon qualifications. Send resume and recent photograph to the Chairman of Chemical Engineering and Chemistry Departments. Fenn College, Cleveland 15, Ohio.

ELECTRICAL AND MECHANICAL Engineering staff openings at Ph.D. and M.S. levels. Salaries commensurate with qualifications. Apply to Dean of Engineering, Duke University, Durham, North Carolina.

ELECTRICAL AND MECHANICAL Engineering positions open. Teaching assignments are Electric Power, Electronics, Mechanical Vibrations, Fluid Mechanics, and other Mechanical Engineering subjects. Salary depends upon qualifications. Excellent fringe benefits. M.S. in Electrical or Mechanical Engineering desired. Applicants with B.S. considered. Write to Earle M. Morecock, Chairman, Applied Science Division, Rochester Institute of Technology, Rochester, New York.

INSTRUCTOR OR ASSISTANT PROfessor in Civil Engineering beginning September, 1957, to teach basic undergraduate courses. B.S. acceptable, M.S. desirable. Location, South. Military College. May-3

WELL-QUALIFIED ASSOCIATE Professor needed for transportation and soil engineering in Civil Engineering Department of large eastern metropolitan university. Excellent salary scale based on nine-month year. May-1

ASSISTANT OR ASSOCIATE MEchanical Engineering Professor experienced in I. C. Engines and Steam Power needed. Write to Mechanical Engineering Department, University of Mississippi, University.

ASSISTANT OR ASSOCIATE PROfessor with M.S. or Ph.D. to teach in expanding department of Electrical Engineering. Wonderful opportunity, excellent salary. Summer employment available. Small congenial faculty at a dynamic municipal university in the Southwest. May-2

EIGHT OPENINGS IN FIELDS OF Drawing, Mechanics, and Civil Engineering. Rank and salary commensurate with qualifications. Industrial Arts degrees considered. Start September. Write to Civil Engineering Department, University Idaho, Moscow, Idaho.

ELECTRICAL ENGINEERING STAFF openings beginning September, 1957. Professor or Associate Professor capable of teaching servomechanisms and electrical theory courses. Instructor or Assistant Professor to teach theory and laboratory courses. Electrical Engineering Department, University of Idaho, Moscow, Idaho.

CIVIL AND MECHANICAL ENGINeering teaching personnel needed in expanding departments of large university. M.S. or Ph.D. required. Openings in all branches at all ranks. Salary and rank will depend upon education and experience. Undergraduate and graduate teaching. Opportunity for research. Location in growing industrial community in central New York. Apply to Dean of Engineering, Syracuse University, Syracuse 10, New York.

ASSISTANT OR ASSOCIATE PROfessors with M.S. or Ph.D. for undergraduate and graduate instruction. Civils with Sanitary training; Electricals with Servomechanisms experience; and Mechanicals with background in Thermodynamics and Fluid Mechanics desired. Twelve-month appointments. Write to Dean of Engineering, University of Akron, Akron 4, Ohio.

ASSISTANT AND ASSOCIATE PROfessors in Department of Thermal Engineering needed to teach Engineering Thermodynamics, Heat Transfer, or Fluid Dynamics. Advanced degrees, teaching or industrial experience helpful. Fine recreational and cultural facilities for entire family. Nine-month teaching contract, salary open, with opportunities for consulting and summer employment on sponsored research. New building (1957), new equipment. Write to Director, Sibley School of Mechanical Engineering, Cornell University, Ithaca, New York.

MECHANICAL AND INDUSTRIAL Engineering Instructors to Associate Professors needed. Ideal college town in Rocky Mountain vacation land. Write to Head of Department, Montana State College, Bozeman, Montana.

AERONAUTICAL OR MECHANICAL Engineer for graduate teaching and research in aerodynamics and/or heat transfer. Opportunity to assume direction of graduate program. Advanced degrees and U.S.A. citizenship required. Year-round employment. Rank and salary open. Write to J. F. Bailey, The University of Tennessee, Arnold Engineering Development Center, Tullahoma, Tennessee.

TEACHING STAFF OPENINGS OF the College of Engineering at the ranks of Instructor or Assistant Professor in Mechanical Engineering. For particulars write to the Dean of Engineering. The University of Nevada, Reno.

ASSISTANT PROFESSOR OR ASSOciate to teach time study and methods courses at the graduate and undergraduate levels, plus the possibility of teaching other industrial engineering subjects. Salary for a nine month year contingent on education and experience; prefer man with advanced degree. Opportunity for graduate study, extra income for teaching evening courses, and for private consulting practice. Position available July 1, 1957. Resume of education and experience should be furnished in initial reply. Write to F. W. Winter, Department of Industrial and Management Engineering, Columbia University, New York 27, New York.

SUMMER EMPLOYMENT FOR ACADEMIC PERSONNEL WITH AEC CONTRACTORS

W. KENNETH DAVIS

Director, Division of Reactor Development
United States Atomic Energy Commission, Washington 25, D. C.

The comments below represent results of a survey conducted by the AEC for the benefit of college faculty members. Though the report was originally prepared for the Atomic Energy Education Committee *News Letter*, the full data are published for possible use this year by those who already hold "Q" clearances, and as general information for those who may wish to apply next year. It is hoped that, if such a compilation proves valuable, a similar one can be obtained next fall.

Conditions of summer employment for 1957 were not indicated by all companies, but stipulations common to several (evidently not to all) are listed below. Each company entry also gives for its organization the types of occupational assignments available, the numbers of positions open in each category or as a total, plus the name and additional postal address data for the representative to whom interested faculty members should direct inquiries.

General Conditions

Employment period: Three months, beginning in June and ending in the latter part of August or early in September.

Salary: Commensurate with the type of assignment, with professional qualifications, present earnings, and other pertinent factors. *Travel expense:* Authorized. *Moving expense:* Not authorized. *Personnel and industrial relations:* Status would be identical to that of permanent staff, except for pension and life insurance benefits.

Deadline for considering applications: March 1, mainly to allow time for "Q" clearance investigation and processing.

Announcement of appointments: Early in May. *AEC "Q" clearance:* Required.

Organizations Interested

UNION CARBIDE NUCLEAR COMPANY — Oak Ridge National Laboratory
Dr. R. W. Johnson, Oak Ridge, Tennessee — Oak Ridge, Tennessee
Biologists 3, chemists 14, metallurgists 3, physicists 13.

UNION CARBIDE NUCLEAR COMPANY — Y-12 Plant, Oak Ridge, Tennessee
Mr. G. W. Flack
Inorganic chemical technology 2, piping design 1, uranium metallurgy 1.

NATIONAL LEAD COMPANY OF OHIO — Cincinnati 31, Ohio
Dr. F. L. Cuthbert, Technical Director; P.O. Box 158, Mt. Healthy Station
Solid state physics, physical metallurgy, extractive metallurgy; total, 5.

MALLINCKRODT CHEMICAL WORKS — St. Louis 7, Missouri
Mr. M. D. Gould, Salaried Personnel Manager, 65 Destrehan Street
Chemical engineering 1, process development 1, inorganic analytical chemistry 1, inorganic chemical research 1, physical metallurgy 1.

GOODYEAR ATOMIC CORPORATION — Portsmouth, Ohio
Mr. W. M. Armstrong, Supervisor, Employment Department, P.O. Box 628
Metallurgy, heat transfer, chemical engineering, electronics, statistics, physical chemistry, analytical chemistry; total positions, 4.

BENDIX AVIATION CORPORATION — Kansas City, Missouri
Mr. R. D. Porter, Employment Supervisor, Kansas City Division
Mechanical, electrical, chemical, industrial engineering; physics, chemistry, metallurgy, mathematics; number of positions not indicated.

BROOKHAVEN NATIONAL LABORATORY — Upton, Long Island, New York
Dr. R. Christian Anderson, Assistant Director
Research in biology and medicine, chemistry, physics, chemical and electrical engineering, all involving the applications of nuclear tools; research and development on nuclear reactor systems; total positions, 50.

SANDIA CORPORATION — Albuquerque, New Mexico
Mr. Brian Finley, Staff Employment Section
Weapons effects, systems analysis, experimental weapons research, aero-dynamics research, electro-mechanical component design, stress analysis, dynamic and static testing; total positions, 20.

THE KNOLLS ATOMIC POWER LABORATORY — Schenectady, New York
Dr. R. E. Hunt, P.O. Box 1072
Nuclear physics 2, theoretical physics 2, applied mathematics 1, metallurgy 1, metallurgy-materials testing 1, chemical engineering 1, heat transfer and fluid flow analysis 1, analytical chemistry 1, mechanical analysis 1.

ALCO PRODUCTS, INC. — Nott Street, Schenectady, New York
Dr. J. L. Meem, Scientific Matters; Mr. J. L. Haines, Engineering Development; 3–4 positions available total for both divisions.

METALS AND CONTROLS CORPORATION — Attleboro, Massachusetts
Mr. J. Ottmar, Vice-President, Nuclear Products Division, P.O. Box 898
General metallurgy, melting of uranium and alloys with aluminum, zirconium, molybdenum, and niobium; chemical assay methods for uranium in alloys; several positions available.

COMBUSTION ENGINEERING, INC. — Windsor, Connecticut
Mr. Frederic Wyatt, Reactor Development Division
Reactor physics, or programming work for high-speed digital computers, 2; heat transfer or stress analysis, 2.

PHILLIPS PETROLEUM COMPANY Idaho Falls, Idaho
Dr. R. L. Doan, Manager, Atomic Energy Division
Nuclear physics theory 2, nuclear physics experimental 2, reactor physics theory 2, reactor physics experimental 3, reactor engineering 2, gamma ray spectroscopy 1, solid state physics 1, research metallurgy 1, radio-chemistry 2, radiation chemistry 2, chemical engineering 2.

GENERAL ELECTRIC COMPANY Richland, Washington
Mr. E. P. Galbraith, Manager, Technical Personnel Placement, Relations and Utilities Operation
Industrial engineers 5, electrical engineers 2, chemists 2, chemical engineers 2, physicists 2, metallurgists 2, mechanical engineers 2.

NOTICE TO EMERITI AND LINGUISTIC WIVES OF OTHERS

The Society recently has received a request from "Executive Services, Inc." for aid in locating interpreters for the International Cooperation Administration. Their program for this year has increased and the need for interpreters is becoming critical, particularly in Spanish, Portuguese, Persian, and Korean.

Interpreters travel with non-English speaking teams visiting the United States to study American methods in various fields under ICA's Technical Assistance Program. Assignments are by project, four to twelve weeks each, subject to acceptance by the interpreter. United States citizenship is not required.

After application is submitted, a language examination is given by the State Department in Washington, D. C. The candidate makes this trip at his own expense. If then recommended, and if there is promise of an assignment, the applicant is given special training by the State Department in Washington, without charge. For detailed information and application forms, write to Executive Services, Inc., 1115 Seventeenth Street, N.W., Washington 6, D. C.

EJC INCOME REPORT AVAILABLE

The Engineers Joint Council report of *Professional Income of Engineers—1956* is now available. This report is based upon engineering income figures for 1956 covering about 100,000 engineering graduates employed in industry, government, and engineering education. Data are presented in various graphic and tabular forms to facilitate analysis, statistical comparison, and the development of trends. Copies can be obtained at $1.50 each, from the EJC office, 29 West 39th Street, New York 18.

DEMAND FOR ENGINEERING GRADUATES, 1956

Report of Special Surveys Committee of EJC

This report presents the summary and evaluation of a survey conducted by the Special Surveys Committee of Engineers Joint Council with the staff assistance of the Engineering Manpower Commission. The survey was conducted during December of 1955 and January and February of 1956 and is based on replies to our questionnaire from 414 industrial and governmental organizations. The 414 organizations which comprise the sample on which this study is based employ about 140,000 engineering graduates or about 25% of the estimated engineering graduates in the U.S.

Summary and Conclusions

One of the most valuable results of the EJC demand studies has been their usefulness in indicating trends in the employment of engineering graduates. The following Table I presents the information from 1952 through the present year in summary form to indicate the overall rough trend during this five-year period.

Although direct numerical comparisons are not suggested (since the survey samples are not strictly comparable) a comparison of trends is certainly admissible. During 1952 the demand for engineering graduates expressed in terms of percentage of net accessions (the total of all new hires minus all losses) was 6.4% of the engineers employed at the beginning of the year. On the same basis, the demand declined somewhat in 1953 and dropped off further in 1954. This trend was reversed sharply in 1955, with a higher demand for engineering graduates than was encountered in the previous peak year of 1952 and this trend continued at a much more accelerated pace through 1956. The percentage of net accessions in 1956 in terms of expected acquisitions is

TABLE I

TREND OF DEMAND FOR ENGINEERING GRADUATES

	Previous Surveys by EJC			Current Survey		
	1952	1953	1954	1955	1956	1956
1. Number of Organizations Reporting	376	376	377	414	414	414
2. Total Engineering Graduates Employed—January 1	117,586	125,086	124,329 (Projected)	132,140	140,446 (Expected)	140,446 (Required)
3. Total Net Accessions Calendar Year	7,500	6,692	5,254	8,306	14,162	20,125
4. Total Engineering Graduates Employed December 31	125,086	131,778	129,583	140,446	154,608	160,571
5. Net Accessions (Per Cent of Engineers Employed on Jan. 1)	6.4	5.3	4.2	6.3	10.1	14.3

10.1%—the highest ever. In terms of required acquisitions, it is 14.3%.

The Reporting Sample

The 414 organizations which supplied usable data for this survey include 363 industrial firms and 51 governmental agencies. The industrial activities employed 111,272 engineers and the government organizations employed 29,174 engineers in federal, state and local agencies. As is indicated by the organization of the various Tables in the Appendix of this report, returns were classified in accordance with the Standard Industrial Classification Code. Those industrial classifications for which the survey provided a reasonably satisfactory sample are classified separately. Those for which the individual samples were insufficient have been classified under the general heading of Other Industries. The Standard Industrial Classification Code numbers of the industries so summarized are listed in the Tables.

In this connection, it is important to realize that in some cases the SIC Code is inaccurate because of the increasing tendency of companies to be active in more than one industrial classification. Since the information is obtained generally, it can only be compiled under that code classification which seems most indicative of the overall activities of any given company.

In undertaking its survey of engineering demand shortly after World War II, the Special Surveys Committee of EJC decided that the most practicable basis for measuring such demand was the needs of the responding companies for engineering graduates rather than for individuals to fill engineering positions. This decision stems from the difficulty of defining engineering positions in a wide variety of organizations and the fact that in recent years individuals sought from outside an organization for work requiring engineering knowledge or skill had been very largely graduates, although comparable positions frequently are filled from within the organization by those developing such skills through experience.

On this same basis, the responding organizations had been asked to indicate their total employment of the need for engineering graduates, regardless of expected assignment recognizing that some may enter upon training for technical supervision or similar fields rather than strictly engineering work.

The total population from which the survey sample is drawn, therefore, is the number of engineering graduates in the country, excluding those who are retired, which at the end of 1955 has been estimated as approximately 560,000 from data of the Commission on Human Resources and Advanced Training—as of 1953 and brought up to date. This compares with the total of about 675,000 individuals classified as engineers in industry, government and other activities as of the same date estimated from the 1950 census and subsequent additions and losses.

The total number of employees in these organizations at the end of 1955 was 3.5 million or about 7% of the total non-agricultural employment of the country and about 11% of the number in the technical fields of Mining, Manufacturing, Transportation and Public Utilities and in Government. The number of engineering graduates in their employ was as heretofore mentioned approximately 140,-

000 of whom 110,000 were industrial companies and 30,000 government agencies. Since this number is about 25% of the estimated number of such graduates in the country, it is clear that these organizations represent a concentration of such men above the average of business, industry and government generally.

Summary Data Provided by Responding Organizations

The total number of graduates required by these organizations in the categories covered are shown in Table II following.

TABLE II

	1955 Actual	1956	
		Expected	Required
1. Number in organization—January 1	132,140	140,446	140,446
2. Total losses during year (all causes, including military)	11,945	10,828	10,828
3. Employment during year:			
A. From current classes:			
a. Bachelors	8,086	11,343	14,524
b. Masters	747	1,119	1,429
c. Ph.D.s	384	600	964
Total	9,217	13,062	16,917
B. From Earlier Classes:	9,133	9.561	11,669
4. Number returning from military leave	1,901	2,367	2,367
5. Total net accessions (3 plus 4 minus 2)	8,306	14,162	20,125
6. Number in Organization—December 31	140,446	154,608	160,571

In this Table, the net accession figure represents the final gain (or loss) in engineering graduate manpower.

Further tabular presentation of the data by industry is provided in the Appendix. Included is a Table on turnover of engineers in 1955 and the breakdown by industry of the demand figures for 1955 and 1956. The heading "Expected" indicates the number the organizations actually anticipate hiring; "Required," the number they estimate are needed based on firm plans and commitments.

Evaluation

The data presented in Tables I and II clearly indicate a rise in demand for engineering curriculum graduates in 1955 and 1956 substantially above that in any year since 1951. There is little question, therefore, that for now and the immediate future government, industrial and other programs effecting engineering graduates should be oriented to and realistically reflect the deficiency indicated.

It is pertinent to ask for the implications of this 1956 survey data for the overall national, industrial and governmental demand for engineering curriculum graduates. A projection of the sample based either on known engineering graduate population or engineering employment in industry and government in the United States would unquestionably be misleading because of the presumption that the needs of the sample represented here are relatively greater than

the economy as a whole. In addition, any overall statistical requirement can be related only to a specific point in time and can be effected rapidly by a whole series of factors acting either independently or in concert. For example, there is little indication here that engineering demand is accumulative over the years. Quite obviously, organizations have learned somehow to perform satisfactorily with undercomplements of engineering personnel. Nevertheless, and considering all factors, the data would seem to warrant the assertion that the situation would be considerably eased if the total number of engineering graduates this year were of an order of magnitude between 35,000 and 40,000.

It should be emphasized that this situation does not necessarily have implications for the intermediate future. Looking ahead to the next three years when the size of the graduating class in engineering will average about 35,000 per year, it is pertinent to note that this increase in the size of graduating classes, combined with a somewhat reduced technological momentum, may have the effect of easing the present situation of extreme shortage. On the other hand, it is clear that given continuing technological activity with a growth factor similar to that of the recent past, there is very little to promise merely numerical relief for the next four years.

Engineering Technicians

In combination with the survey of enginering graduate demand, a survey of the demand for engineering technicians was conducted. The summary is presented in Table VII of the Appendix. It should be noted that the number of replies and the engineering graduate force of this Table are not the same as shown in the engineering demand Tables because many of the organizations failed to provide information on their technician force. The term technician was intended to include those employed who were in technical positions by virtue of education in technical institutes (after high school graduation) or by on-the-job training.

It is apparent that industry is coming to recognize the importance of the technician in the overall engineering manpower situation. The ratio of technician to engineer varies considerably among the various industries and averages 0.73 for the reporting segments of industry and government. However, in terms of new hires for 1956 the ratio is found to be over 1.00 which leads to the conclusion that demand for technicians is roughly comparable to the demand for engineering graduates.

Among organizations employing engineers, those indicating strongest demand for graduates in 1956 are the same which indicate demand for engineering technicians. (It should be noted that under classification 48—Telecommunications—the data differs from the average, for reasons of their peculiar well known high demand for technicians which are, in general, trained on the job by the companies.) This no doubt indicates that these companies are seeking to place technicians in as many positions as they are capable of fulfilling thereby releasing engineers for positions more in keeping with their abilities, or in other words, seeking partial relief to the shortage of engineering know-how by better utilization of the talents of the engineers available.

APPENDIX

TABLE III

BREAKDOWN BY INDUSTRY OF ACTUAL ENGINEERING EMPLOYMENT, 1955

Industry	SIC Code	Number of Returns	Total Engrs. in Employ 1/1/55	Total Losses All Classes	Employment 1955				From Earlier Classes	Returns from Military Leave	Total Net Accessions	Total Engrg. Graduates in Employ 12/31/55	B.S. Hires as % of Total Engrs. Employed	B.S., M. S. Ph.D. Hires as % of Total Engrs. Employed	Hires Exper. Engrs. as % of Total Engrs. Employed
					B.S.	M.S.	Ph.D.	Total							
Total of industry and government		414	132,140	11,945	8,086	747	384	9,217	9,133	1,901	8,306	140,446	6.1	7.0	6.9
Total industry		363	103,599	8,395	6,493	689	380	7,238	7,238	1,268	7,673	111,272	6.3	7.3	7.1
Chemicals and allied products	28	28	14,165	933	821	108	37	966	485	78	596	14,761	5.8	6.8	3.4
Machinery (except electrical)	35	40	4,419	619	233	19	5	257	274	9	−79	4,340	5.2	5.8	6.2
Electrical machinery equipment & supplies	36	44	32,127	2,471	2,356	166	213	2,735	2,427	809	3,500	35,627	7.4	8.5	7.6
Transportation equipment	37	22	10,380	1,099	759	89	23	871	1,668	54	1,494	11,874	7.3	8.4	16.1
Professional & scientific instruments	38	12	3,260	265	247	25	5	277	335	21	368	3,628	7.6	8.5	10.3
Public utilities, operating telephone companies & railroads	40 48 49	62	16,365	793	499	13	—	512	358	139	216	16,581	3.0	3.1	2.2
Misc. services: consulting firms, research & development	89	75	10,941	1,233	773	151	67	991	1,325	40	1,123	12,064	7.1	9.1	12.1
Products of petroleum and coal	29	15	6,685	580	486	84	24	594	133	84	231	6,916	7.3	9.0	2.0
Other industries	10,11,13, 14,15,19, 20,22,24, 26,30,31, 32,33,34, 52	65	5,257	402	319	34	6	359	233	34	224	5,481	6.0	6.8	4.4
Government	90	51	28,541	3,550	1,593	58	4	1,655	1,895	633	633	29,174	5.6	5.8	6.6

TABLE IV

Breakdown by Industry of Expected Engineering Employment, 1956

Industry	SIC Code	Number of Returns	Total Engrs. in Employ 1/1/56	Total Losses All Classes	Employment 1956				From Earlier Classes	Returns from Military Leave	Total Net Accessions	Total Engrg. Graduates in Employ 12/31/56	B.S. Hires as % of Total Engrs. Employed	B.S., M.S., Ph.D. Hires as % of Total Engrs. Employed	Hires Exper. Engrs. as % of Total Engrs. Employed
					B.S.	M.S.	Ph.D.	Total							
Total of industry and government		414	140,446	10,828	11,343	1,119	600	13,062	9,561	2,367	14,162	154,608	8.1	9.3	6.8
Total industry		363	111,272	7,660	9,301	1,014	590	10,905	7,694	1,818	12,757	124,029	8.4	9.8	6.9
Chemicals and allied products	28	28	14,761	838	910	121	57	1,088	437	808	808	15,569	6.2	7.4	3.0
Machinery (except electrical)	35	40	4,340	361	555	35	12	602	346	65	652	4,992	12.8	13.9	8.0
Electrical machinery equipment & supplies	36	44	35,627	2,445	3,219	294	324	3,837	2,263	1,016	4,671	40,298	9.0	10.8	5.3
Transportation equipment	37	22	11,874	1,150	1,259	166	53	1,478	2,154	113	2,595	14,469	10.6	12.5	18.1
Professional & scientific instruments	38	12	3,628	295	377	26	9	412	394	36	547	4,175	10.4	11.4	10.9
Public utilities, operating telephone companies & railroads	40 48 49	62	16,581	668	787	13	—	800	325	157	614	17,195	4.8	4.8	1.9
Misc. services: consulting firms, research & development	89	75	12,064	1,070	1,083	214	82	1,379	1,526	120	1,955	14,019	9.0	11.4	12.7
Products of petroleum and coal	29	15	6,916	545	649	104	42	795	90	134	474	7,390	9.4	11.5	1.3
Other Industries	10,11,13, 14,15,19, 20,22,24, 26,30,32, 32,,33,34, 52	65	5,481	288	462	41	11	514	159	56	441	5,922	8.4	9.4	2.9
	90	51	29,174	3,168	2,042	105	10	2,157	1,867	549	1,405	30,579	7.0	7.4	6.4

TABLE V—BREAKDOWN BY INDUSTRY OF REQUIRED ENGINEERING EMPLOYMENT, 1956

Industry	SIC Code	Number of Returns	Total Engrs. in Employ 1/1/56	Total Losses All Classes	Employment 1956				From Earlier Classes	Total Net Accessions	Total Engrg. Graduates in Employ 12/31/56	B.S. Hires as % of Total Engrs. Employed	B.S., M.S., Ph.D. Hires as % of Total Engrs. Employed
					B.S.	M.S.	Ph.D.	Total					
Total of industry and government		414	140,446	10,828	14,524	1,429	964	16,917	11,669	20,125	160,571	10.3	11.7
Total industry		363	111,272	7,660	11,121	1,233	939	13,293	9,419	16,870	128,142	10.0	11.9
Chemicals and allied products	28	28	14,761	838	1,116	151	99	1,366	486	1,135	15,896	7.6	9.3
Machinery (except electrical)	35	40	4,340	361	738	49	49	804	394	902	5,242	17.1	18.7
Electrical machinery equipment & supplies	36	44	35,627	2,445	3,364	346	556	4,266	2,622	5,459	41,086	9.5	11.8
Transportation equipment	37	22	11,874	1,150	1,772	239	91	2,102	3,059	4,124	15,998	15.0	17.8
Professional & scientific instruments	38	12	3,628	295	521	30	10	561	645	947	4,575	14.4	15.5
Public utilities, operating telephone companies & railroads	40 48 49	62	16,581	668	1,188	16	—	1,204	476	1,169	17,750	7.2	7.3
Misc. services: consulting firms, research and development	89	75	12,064	1,070	1,212	235	100	1,547	1,477	2,074	14,138	10.1	12.8
Products of petroleum and coal	29	15	6,916	545	704	126	51	881	89	559	7,475	10.2	12.8
Other industries	10,11,13,14, 15,19,20,22, 24,26,30,31, 32,33,34,52	65	5,481	288	506	42	15	562	171	501	5,982	9.3	10.8
Government	90	51	29,174	3,168	3,403	196	25	3,624	2,250	3,255	32,429	11.7	12.1

TABLE VI

TURNOVER OF ENGINEERS, 1955

Industry	SIC Code	Number of Returns	Total Engrs. in Employ 1/1/55	Total Losses All Classes	Losses as % of Total Engrs. in Employ 1/1/55	Total Net Accessions	Net Accessions as % of Total Engrs. in Employ 1/1/55
Total of industry and government		414	132,140	11,945	9.0	8,306	6.3
Total industry		363	103,599	8,395	8.1	7,673	7.3
Chemicals and allied products	28	28	14,165	933	6.6	596	4.2
Machinery (except electrical)	35	40	4,419	619	14.0	−79	(−1.8)
Electrical machinery equipment & supplies	36	44	32,127	2,471	7.7	3,500	10.9
Transportation equipment	37	22	10,380	1,099	10.6	1,494	14.4
Professional & scientific instruments	38	12	3,260	265	8.1	368	11.3
Public utilities, operating telephone companies and railroads	40, 48, 49	62	16,365	793	4.9	216	1.3
Misc. services: consulting firms, research & development	89	75	10,941	1,233	11.3	1,123	10.3
Products of petroleum and coal	29	15	6,685	580	8.7	231	3.5
Other industries	10,11,13,14, 15,19,20,22, 24,26,30,31, 32,33,34,52	65	5,257	402	7.6	224	4.3
Government	90	51	28,541	3,550	12.5	633	2.2

TABLE VII

BREAKDOWN BY INDUSTRY OF EMPLOYMENT AND DEMAND OF ENGINEERING TECHNICIANS

Industry	SIC Code	Number of Returns	Total Engineers Employed	Technicians Employed	Ratio of Technicians to Engineers	Technicians to be Hired 1956	New Hires as % of Total Employed
Total of industry and government		356	93,823	68,521	0.73	16,689	24.4
Total industry		315	73,575	53,825	0.73	13,864	25.8
Chemicals and allied products	28	16	1,422	314	0.20	26	8.3
Machinery (except electrical)	35	35	3,316	2,182	0.66	499	22.8
Electrical machinery equipment & supplies	36	40	23,818	21,950	0.92	4,879	22.2
Transportation equipment	37	19	6,533	2,803	0.43	911	32.5
Professional & scientific instruments	38	11	3,466	1,546	0.45	140	9.1
Railroads, telecommunications	40,48	23	8,453	11,857	1.41	5,148	43.5
Utility & sanitary services	49	31	6,485	2,372	0.37	298	12.5
Miscellaneous services: consulting firms, research & development	89	68	10,301	5,256	0.51	1,466	28.9
Products of petroleum & coal	29	13	5,577	1,381	0.25	166	12.0
Fabricated metal products	34	13	973	3,099	3.18	216	7.0
Other industries	10,11,14,20, 22,24,26,30, 32,33	46	3,231	1,065	0.33	115	10.8
Government	90	41	20,248	14,696	0.87	2,825	19.2

LOGICAL VARIATIONS IN THE RESEARCH POLICIES OF EDUCATIONAL INSTITUTIONS

Edited by H. W. BARLOW

A summary of comments by KURT F. WENDT, J. H. MULLIGAN, and F. C. LINDVALL

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Presented at a closed session of the Engineering College Research Council, June 27, 1956, Ames, Iowa. The colleges reporting were chosen to typify a Midwest state university, a large private eastern university in an urban environment, and an endowed West Coast Engineering College.

Introduction

Because of the increasing participation by educational institutions in both government-sponsored and industry-supported research projects, many new problems have arisen which had not been faced previously. Research and other college administrators, and the governing boards of educational institutions, have therefore adopted varied policies which seemed to fit their needs in the light of their basic educational aims, their responsibilities to their communities, states, and the nation, and the precedents established by long usage.

Circumstances change, however, and successful experimentation often has indicated that reasonable variations or differences in policy can be introduced which result in gains to the institution without sacrifice of integrity or damage to basic principles. These changes are brought about when college administrators confer with their colleagues, consult published statements on research administration, or when research or academic administrators persuade their presidents and governing boards of the desirability of modification in order that the institution may keep pace with developments.

Under the auspices of the Committee on Research Administration of the Engineering College Research Council, a nation-wide meeting was held so that research directors and college administrators could examine and discuss some of these variations in research policies from one educational institution to another. It is highly probable that there are more variations than similarities in the policies that affect the administration of research. In presenting this session, the committee hoped that these variations could be shown to be not irrational, but entirely feasible, and that research can be conducted profitably and with benefit to institutions under a variety of policies.

Description of Institutions

To appreciate and evaluate fairly the research policies, readers may find helpful some information about the reporting institutions.

The University of Wisconsin is a State University and the Land Grant College of that state. It has had an Engineering Experiment Station since 1914, but until 1946 this was almost entirely a "paper" organization.

Primarily the Station was an association of teaching staff members who were interested in research and who found some time to pursue investigations after discharging their teaching duties. The station had no direct financial support from the Legislature. During and immediately following World War II, there was a virtual absence of on-campus research except in a few exceptional and quite notable areas. Early in 1946, however, the administration and faculty of the college determined to create a means of renewing activity in this important phase of education. The Legislature provided an appropriation, and a staff member was given the responsibility of carrying out faculty directives. From this beginning, a program was developed for which the annual budget is currently about $450,000.

New York University is a privately endowed, non-sectarian institution, one of the largest in the country. It receives neither state nor city aid and is not connected with any tax-supported institution.

During the fiscal year 1954–55 more than $7.5 million dollars of research contracts and grants were negotiated during the year in all branches of the university, including the Medical Center. Of this total, approximately $2.3 million dollars were for medical research, and very nearly $2.7 million dollars were for the research division of the College of Engineering.

During that period 265 research personnel were employed on a full-time basis in the research division of the College of Engineering with 111 working part-time on research. Some 55 additional individuals were employed by the research division in service or administrative capacities.

California Institute of Technology is a privately endowed institution. The review of current research of the ECRC for the year 1953 reports research expenditure of the California Institute of Technology for the year 1951–52 of $1,241,532.

Research Administration Policies and Practices

Each of the three speakers was given a list of questions well in advance of the meeting, and was asked to answer them in the light of the policies and practices of his institution. The first question concerned the role of research at the institution, the second concerned the basic reasons for this role and how they are stated as a policy, and the third asked for a description of ways in which this research policy was implemented with respect to fourteen different practices and policies.

Although it was indicated in the planning of the meeting that the remarks of the three speakers would not be primarily for publication; each of them has agreed that this restriction can be eliminated.

The remainder of this article will consist of the contributions of these three authors to the basic questions propounded them. Their replies will be identified as follows: *WIS*—Uni-

versity of Wisconsin; *NYU*—New York University; *CIT*—California Institute of Technology.

Questions and Discussion

Q:—*What is the role of research in your institution?* (I.e., what are the broad objectives:—to provide an outlet for faculty interests; to solve basic problems; to provide financial and other assistance to graduate students in connection with theses and dissertations; to assist industry in the state, region, or nation; to assist the state or federal government?)

WIS: Research in engineering at the University of Wisconsin is basically under the general direction of the Engineering Experiment Station. The Engineering Experiment Station is charged with the following responsibilities:

(1) To provide the teaching staff with professional opportunities for full-time work in the station on research and process development during an occasional semester's leave of absence or summer vacation.

(2) To centralize the administration of various testing laboratories serving the general public. Examples are the Gage Laboratory and the Electrical Standard and Instrumentation Laboratories.

(3) To provide opportunities for cooperation among the different departments of the college and with other departments of the University on research projects which demand collaboration in several areas.

(4) To provide special buildings or space for experimental projects which do not properly fall in any one department or which for reasons of safety, extent of facilities, and convenience should be detached from classrooms and undergraduate laboratories.

NYU: The primary function of the College of Engineering is the education of students: undergraduate, graduate, and special. The primary function of the faculty and regular staff is the instruction of such students. Such instruction, particularly on the graduate level, frequently requires ability in and performance of research.

It is recognized that staff members cannot devote their entire efforts to teaching and at the same time keep abreast or ahead of progress in the scientific or engineering area with which they are concerned. It is desirable, therefore, that staff members engage to a greater or lesser extent in research, consultation, or professional and technical writing; such non-curricular activities serve to enhance the knowledge of the faculty member, stimulate his teaching, and bring prestige to the individual and to the educational institution.

CIT: In all the scientific and engineering departments of the institute, research is made a large part of the work. This is done not only because contributing to the advancement of science and thus to the intellectual and material welfare of mankind is important, but also because without research the educational work of an institution of higher learning lacks vitality, fails to develop originality and creativeness in its students. To insure the development of research, the Trustees will provide for it financially, not (as is so often the case) out of the residue that may be left

after meeting the demands of the undergraduate work, but by duly limiting the extent of this work and by setting apart in advance funds for research and graduate study. It is also the policy of the Trustees to make the advancement in grade and salary of members of the staff largely dependent on accomplishments in research or in other creative directions.

Q:—*What are the basic reasons for this role and how are they stated as a policy?*

WIS: The two prime objectives of the Station are:

(1) To promote engineering education by encouraging, fostering, and conducting scientific investigations and industrial research, and to train and develop persons for the conduct of research.
(2) To render public service by cooperating with industries, manufacturers, and professional engineers in the solution of broad fundamental problems of general interest to each of these groups.

NYU: It is the policy of the college to undertake, as a rule, only such sponsored projects as (a) seem likely to add to knowledge of fundamental or applied science; (b) are financed by the sponsors on a basis which allows for allocating part of the gross fee to the Research Fund for the promotion of college-sponsored research; (c) have as an objective the training or further training of one or more research workers; (d) extend over a reasonably long term, preferably a year or more; (e) do not conflict with any other current projects or sponsors; (f) are of such a nature that they do not compete with, or cannot be successfully undertaken by, a commercial testing laboratory. In periods of national emergency, priority will be given to research projects which are directly concerned with national interests and needs.

CIT: The Institute recognizes its obligation to serve the community, industry, and private foundations or governmental agencies through sponsored research projects, and is at the same time mindful of the benefits to be derived by the Institute from such activities. The interests of the Institute and the sponsor can best be served, however, if the Institute retains its status as an independent organization engaged in education and research. To that end the following policies have been established:

(1) Only those faculty members approved by the division chairmen concerned may apply for, or serve as directors of, sponsored research.
(2) Contracts, agreements, or other arrangements with sponsors will be governed by the following provisions:
    (a) The scope of the work shall involve fundamental research likely to add to the knowledge of natural laws and processes, falling clearly within the Institute's educational and research program, supplementing or making a positive addition to that program, and being of such a nature that the Institute would undertake the research if its own funds were adequate.

(b) The Institute shall be free to publish the results of the sponsored research.

(3) Contracts for work falling outside the Institute's normal program may be undertaken for the government in times of emergency, or if the work constitutes an important contribution to the national defense or welfare, or if it in other ways performs some unique service to the community.

(4) The Institute has certain unusual, even unique, equipment and facilities for conducting tests and investigations of various kinds. When mutually advantageous arrangements can be agreed upon, and when the work cannot as well be conducted in the sponsor's or in a commercial laboratory, such facilities may be used for conducting tests or investigations for outside agencies. Alternatively, the Institute may undertake to design, to build, and to operate such special facilities on a sponsored basis.

(5) Faculty members serving as directors of, or assigned to participate in sponsored research (whether or not any portion of the individual's salary is charged to the sponsored account) shall not by virtue of such arrangement receive an extra stipend. When, in the judgment of the President, the direction of important Institute affairs (whether sponsored or not) warrants an adjustment in salary, the individual involved may be awarded an increase in recognition of his enlarged responsibilities. Such an increase may be clearly designated as contingent upon continuation of the additional responsibilities or activities, and the individual will be informed as to what portions, if any, of his salary are on a contingent basis.

At the present time no deviation from the stated policy of no extra compensation has been made, except for a Professor who is on full-time leave of absence as the Director of the Jet Propulsion Laboratory.

The Jet Propulsion Laboratory is an entirely off-campus facility which is wholly owned by the government and is operated by the Institute on contract under the principle stated in Item 3 above. An additional facility, the Southern California Cooperative Wind Tunnel, which is owned by five aircraft companies, is also operated on contract by the Institute as an off-campus installation. These two off-campus facilities, employing some 1600 people, are administratively independent of the academic divisions of the Institute and are responsible directly to the President and the Trustees.

Q:—*How is this research policy implemented with respect to the following fourteen items:*

1. What methods are applied to determine a staff member's full load"?

WIS: The usual full load for a staff member is twelve (12) credit hours or its equivalent. In determining this equivalent, account is taken of undergraduate and graduate thesis assignments and also of unusually heavy committee assignments in the University, or participation in the Milwaukee Evening Graduate Program.

NYU: A full-time academic staff member is assigned a teaching load of twelve (12) to fourteen (14) equivalent lecture hours. A fifty-minute lecture period, offered once per week, is evaluated as one equivalent lecture hour, whereas a three-hour laboratory meeting once per week is equal to two equivalent lecture hours.

CIT: In view of the long-established research policy, teaching loads at the Institute are understandably light. No formal mechanism exists for computing "a full load" of teaching, research, committee work, thesis supervision, and so on. Adjustment in teaching load or other responsibility is made in individual cases when an abnormal situation has developed for one reason or another.

2. What, if any, overloads are permitted? What are maximum allowable loads, including research?

WIS: We do not allow overloads.

NYU: At the present time members of the professorial staff may elect to participate in sponsored research activity to a maximum extent of five clock hours per week above base teaching or research loads.

CIT: No formula or method exists for determining overloads or maximum allowable loads. For graduate students who are employed on research projects, the maximum allowable load is 62 clock hours per week of total academic load plus employment. This is monitored by the Dean of Graduate Studies.

3. What are methods, amounts, and rates of compensation for overload and overtime service?

WIS: Since no overload or overtime service is recognized, no additional compensation is authorized for participation in special contracts or special teaching assignments.

NYU: The amount of extra compensation received for this additional effort is a function of the amount of research assigned as part of the base load. In the event that no research is assigned as a part of the base load, the compensation for the additional effort is then maximized and is equal to nearly 14% of the base salary.

CIT: Because extra compensation for sponsored research is not permissible, no procedure has been evolved for computing extra pay for overload or extra-time service.

4. What are basic differences in compensation for the same period of annual service for the following groups? If these differences exist, how are they established?

(a) *Regular academic faculty and staff members.*
(b) *Regular research faculty and staff members.*
(c) *Split assignments for regular faculty and staff members.*
(d) *Sponsored research faculty and staff members.*

WIS: There are no basic differences in compensation. When academic staff, paid on an academic basis, is used during the summer, the rate of compensation is exactly the same as during the academic year (based on ten months), namely, 10% of the academic salary per month of summer service to the institution.

NYU: There are no basic differences in compensation. Academic staff members may participate to a maximum of two months employment on sponsored research contracts during

the summer. For the two months of work they receive two-ninths of their base pay.

CIT: The academic faculty includes instructor through professor grades and Research Fellows (a post-doctoral title). Also included in faculty are lecturers, who are part-time. Non-academic personnel include all those engaged in normal non-instructional work at the Institute, plus the employees of the Jet Propulsion Laboratory and Cooperative Wind Tunnel.

Academic compensation is on a twelve-month basis with one month vacation. The non-academic staff may be compensated on an hourly or monthly basis, depending upon position and status. In general the non-academic staff is paid at going area rates, with the result that most of the professional people who are engaged in research at the Jet Propulsion Laboratory and the Cooperative Wind Tunnel are paid at rates substantially higher per year than their professional equals on the academic faculty.

Non-academic personnel cannot, however, acquire tenure. Fringe benefits are roughly comparable to those of the faculty, including earned vacations up to one month for fifteen years of service. Formal consulting privileges are restricted to faculty.

Five faculty members have split responsibilities with the Jet Propulsion Laboratory and the Cooperative Wind Tunnel. The salary of these men is their academic salary, and their compensation for the time they spend for the off-campus facilities is accordingly lower than it would be in the same position were they on full-time off-campus status.

5. Are the research program and staff integrated with the teaching program and staff; if so, to what extent and by what means?

WIS: Every attempt is made to integrate research and teaching programs through the college so that the same staff is used for both functions. It is very rare to have a staff member functioning solely on research without regular academic status. Occasionally, of course, one of the regular teaching staff may be freed entirely from teaching responsibilities for a semester or even for a year to undertake a specific research assignment, but he continues and retains his academic status.

NYU: A definite effort has been made to integrate research and teaching activity in the College of Engineering. As has been indicated before, details of the integration vary from department to department. In most, project directors are selected from the professorial staff. This action, in itself, contributes materially to the integration of teaching and research activities.

In some instances it is more expedient to have a research employee as a project director, with a faculty member acting as the technical adviser. For the most part the academic departments have been given freedom to work out, in conjunction with the Director of the Research Division, patterns of operation which the department members feel best meet their particular needs.

The integration of teaching and research activity takes various forms. On the one hand, some of the research personnel teach graduate and evening undergraduate courses as well as take graduate work toward advanced degrees. On the other hand, members of the teaching staff

who normally have a full-time academic appointment participate in research work on many projects.

CIT: The campus research programs are well integrated with teaching. Graduate students participate in sponsored as well as unsponsored research. The large number of young post-doctoral Fellows engaged in research are in a sense extending their training for the year or two they hold these positions. At the same time, these Research Fellows work closely with graduate students, participate in general and divisional faculty meetings, and serve on doctoral or other degree committees.

6. What are the "fringe benefits" applicable to faculty or staff employed solely on research, at the institution, especially with regard to such items as academic recognition, tenure, group life or health insurance participation, and salary differentials?

WIS: In the occasional instance when a person may be hired as a project associate or project assistant for a limited period of time to engage in research, he becomes eligible for the regular group life and health insurance and retirement benefits accorded to faculty, but does not obtain tenure. Normally there is also no salary differential.

NYU: In general, similar conditions of employment obtain for the two types of scientific worker in the College of Engineering. "Research Staff" applies to persons employed on a full-time basis for work on sponsored research projects, whereas "Academic Staff" includes persons whose full-time employment is primarily devoted to the instruction of undergraduate and graduate students.

A research staff member is ordinarily appointed without tenure, as are academic staff members of the rank of "Instructor" and "Assistant Professor." Appointments to the rank of "Associate Professor" and "Professor," however, carry permanent tenure if the reappointment is for the fourth year as a full-time professor or for the sixth year for a full-time associate professor.

A number of miscellaneous benefits for both research and academic staff members are also available. Members of the research staff are entitled to tuition remission for a maximum of three graduate courses per term. Members of the teaching staff with the rank of "Instructor" or above are entitled to remission of the normal tuition fees in courses for which they may be eligible, without restriction as to the number of courses that may be taken per term.

Further, New York University cooperates with the Teachers Insurance and Annuity Association of America in a retirement annuity plan. Faculty members who hold the rank of Assistant Professor" and above are required to participate in the plan from the date of appointment, whereas personnel with the rank of instructor are eligible to participate after one year of full-time service.

Research staff members are eligible to participate in the plan after five years' full-time continuous service. Life insurance on a group basis is available to both research and academic personnel.

CIT: No faculty member of the rank of "Instructor" or higher is employed solely on research. Appointees in the faculty category acquire tenure, under regulations essentially

those recommended by AAUP. No other appointees may acquire tenure. Academic recognition for Research Fellows comes through faculty membership at the Institute.

The Institute extends fringe benefits to all employees in the form of Workmen's Compensation Insurance, Old Age and Survivor's Insurance, and group insurance. Beyond the academic, TIAA retirement is available to all Institute employees who have been employed by the Institute not less than three years. Seven per cent of salary is contributed by the individual and seven per cent by the Institute. Health insurance participation is optional, and the Institute makes no contribution to this type of protection. Salary differentials favoring non-academic employees are tolerated, as explained earlier.

7. Are teaching and research faculty members allowed to do outside consulting work, and if so, under what restrictions?

WIS: Both teaching and research faculty members are permitted to do consulting work which is reasonable in amount and which does not interfere with their regularly assigned duties. A lengthy statement of policies on outside activities is part of the laws and regulations governing the University of Wisconsin.

These provide generally that, within the above limits, the administration should be kept advised in writing of the nature and scope of such activities through the Chairman of the individual's department. Also, the President should be consulted concerning cases involving major sums of money, extensive time, or work which is related to matters of public policy. Permission to do such work may be denied, but there is provision for appeal from the department chairman or the Dean to the President and eventually to the Board of Regents.

NYU: In general, members of the professorial staff are permitted one day per week for outside consulting activities in their fields.

With the exception of special cases, in which the permission of the Director of the Research Division is required, research staff members are not permitted to do outside consulting work. Participation on committees of technical societies, and in outside professional activities of a similar nature is strongly encouraged, however.

CIT: Academic faculty, including Research Fellows, are permitted an average of one day a week throughout the year for consulting work. There is no formal supervision of consulting practice in terms either of days worked or dollars earned. The individual's conscience must be his guide; in the event of an excessive or emergency consulting demand, however, it is expected that a partial leave of absence should be requested.

8. Is provision made for termination pay, sick leave, and annual leave?

WIS: Except for civil service employees, the University of Wisconsin does not have a published sick leave policy. Each case is handled on its merits, and ordinarily means are found to continue salary payments for a reasonable period of time in the case of prolonged illness.

Annual leave for annual appointments is one month per calendar year. Except in very special short time cases, most appointments are on an annual basis, and such appointments are reconfirmed several months in ad-

vance of the termination date. There are no provisions for termination pay.

NYU: Research employees accumulate vacation at the rate of 1⅔ days per month, starting with July 1 of each year. In addition, they obtain the one-day holidays available to academic staff members, plus a limited amount of additional time at Christmas vacation and Easter recess.

CIT: Termination pay and sick leave for non-academic personnel follow general area employment practices. Faculty termination is in accordance with AAUP recommendations. Sick leave for faculty is completely informal and generous. Annual leave for faculty is one month and for non-academic up to one month after fifteen years of service.

9. What specific types of sponsored research programs or projects are accepted?

WIS: Sponsored research programs and projects of any type are accepted by the Engineering Experiment Station, provided the work is of interest to one or more faculty persons who are willing to accept the responsibility for the project, and provided further that the work is of such character as to be acceptable for Master's and Doctoral dissertations. Routine testing is not accepted.

NYU: Stated under Item B above as a matter of basic policy.

CIT: Stated under Item B above as a matter of basic policy.

10. Are state-appropriated funds used for applied research of value to the public or to the state?

WIS: For many years there were no state-appropriated funds for research by the Station. At the present time, however, about 20 per cent of the Station's $450,000 annual budget comes from state appropriation. Through conscious effort on the part of the administration, support for research comes from a variety of sources, and a balance is maintained in such support. As far as possible, the aim is to maintain about equal assistance from state appropriations, industrial grants, federal contracts, and grants-in-aid from the Wisconsin Alumni Research Foundation.

NYU: Not applicable.

CIT: No publicly appropriated funds come to the Institute other than sponsored research under the usual Government contracts.

11. Are teaching staff members used as "technical consultants" (with fees) to research projects?

WIS: Our teaching staff may serve on research projects, but without extra compensation during the academic year. In serving as a technical consultant, no extra fees are permitted on projects within the University except during the summer months when the faculty member is not on salary. When a faculty member does serve in such a capacity during the academic year, however, suitable provision is made for reduction in teaching assignments.

NYU: Academic staff members are not permitted to act as extra-pay "consultants" for sponsored research projects at the university.

CIT: Members of the teaching staff may not, as technical consultants, receive compensation from Institute research activities, including the Jet

Propulsion Laboratory and the Cooperative Wind Tunnel.

12. Do staff members, as inventors, participate in any income from patented discoveries?

WIS: The University of Wisconsin does not have a formal policy on patents, but has traditionally held that any patentable discovery or invention becomes the property of the individual responsible for the discovery. The only exceptions to this general rule are cases involving federal contracts, where in the interest of the national defense the federal government requires at least a use patent to be reserved for the government. In all other instances the inventor or discoverer is free to dispose of his patent rights in any way he chooses.

Many of our readers will, however, be interested in the Wisconsin Alumni Research Foundation arrangements on patents. This Foundation was created about 1925 to process the Steenbock Vitamin D patents, since Dr. Steenbock did not wish to benefit personally and the University could not accept the patent for itself.

Subsequently the Foundation agreed to accept other patents from the faculty on assignment, and now has adopted the policy of returning to the inventor or discoverer 15 per cent of the net proceeds. Assignment of patents to the Foundation is not required, but since a fine organization has been set up not only to prosecute patent claims at no expense to the individual but also to secure licensed users of patents, most faculty people feel that the arrangement is a very attractive one and they use it accordingly.

Another advantage is that the Foundation annually provides funds for research in the physical sciences. These Foundation grants have been increasing steadily, and this year exceed one million dollars.

NYU: Both academic and research staff members are affected by an agreement which the University has entered into with the Research Corporation. In the event that an invention is produced, it is the policy of the University to offer the invention to the Research Corporation. If accepted by that corporation, both the University and the inventor assign to the Corporation all rights, title to, and interest in the invention. Normally, however, the inventor is paid 15% of the net proceeds.

CIT: All staff members and faculty members assign patentable discoveries to the Institute. Should income from such inventions exceed patent application and patent administration costs, the inventor is entitled to 15% of the excess of returns over expenses.

13. What "service charge," allocable to overhead payments received for sponsored research projects, must be paid to the University general or special funds as University overhead?

WIS: Overhead payments received for support of research projects are paid into special University fund accounts. On government projects, the adjusted overhead rate based on salaries and wages is now about 32%. In industrial contracts approximately the same yardstick is used, but other contributions by the industry in the way of special equipment and lack of restriction may be taken into account to adjust this rate.

NYU: An overhead charge, computed on a basis of indirect labor cost (50.4% for "on-campus" projects and

30.0% for "off-campus" projects), is made on all sponsored research projects. The income from this source goes into the general account of the university. Various percentages of these funds are then set aside for research expenses not directly chargeable to research contracts, such as the purchase of special equipment and the maintenance of equipment and facilities for research.

CIT: Of the overhead payments received by the Institute on sponsored research contracts, all go into the general budget of the Institute except 10% set aside in a reserve fund for replacement and maintenance of general facilities on an Institute-wide basis. No other "service charges" are made against contracts or projects. Individual projects utilizing Institute facilities which are not included in general overhead computation pay a nominal departmental or shop burden on direct labor for service rendered.

14. What proportion, if any, of "overhead" payments received by the University is reassigned to the department carrying on the project, for such purposes as the support of further fundamental research, fellowships, or repairs of equipment used on the project?

WIS: A very large percentage of the total overhead funds has been made available for repairs of equipment, refurnishing of quarters, replacement of obsolete equipment, and for similar purposes, if not in the department in which the overhead was earned, at least within the same subdivision of the university.

NYU: A part of the overhead is credited to the department carrying on the project, for the support of further research.

CIT: No part of overhead payments received by the Institute is reassigned to the department conducting the particular project research. All repairs or maintenance, except those directly chargeable to the contract, come from the general reserve account.

WORCESTER POLYTECHNIC INSTITUTE GRANT

The Olin Foundation has announced a grant of $1,229,000 to Worcester Polytechnic Institute, Worcester, Massachusetts, to provide a new physics building. The new building will include instructional laboratories, research laboratories, a lecture room, office, and classrooms. A Nuclear Science Laboratory is included among the research facilities.

The physics building will be the second of Worcester's buildings to be financed in the $5,500,000 development program. The first building is a $1,250,000 dormitory which will include residence for 200 students and dining facilities for all students and faculty members on the campus.

NEW PUBLICATIONS AVAILABLE

MANPOWER AND EDUCATION

The Education Policies Commission has recently published a new report, *Manpower and Education,* which brings together widely scattered information on the educational needs and trends in relation to the manpower shortage. Part I of the report reviews the factors contributing to the present manpower shortages, identifies the areas in which shortages will be acute, and appraises the nation's under-used resources of manpower which can, through increased education and training, relieve the problems in the shortage areas.

Part II points to the need for consideration of democratic values in the determination of manpower policy. The implications for education at all levels are discussed in Part III. The recommendations which conclude the report apply to schools, colleges, and agencies for adult education. The illustrated 128 page booklets are available at $1.25 per copy from the National Education Association and the American Association of School Administrators, *Educational Policies Commission,* 1201 Sixteenth Street, Northwest, Washington 6, D. C.

SANITARY ENGINEERING EDUCATION REPORTS

Two reports of the Subcommittee on Graduate Academic Education, Committee on Training, Engineering and Sanitation Section, American Public Health Association, are available without charge from the ASEE representative on the committee, Professor G. H. Dunstan, State College of Washington, Pullman.

First, the *Final Report, November, 1955,* discusses the scope and character of sanitary engineering education at schools of engineering. It gives information, obtained from a questionnaire returned by 125 engineering schools, as to sanitary engineering courses required of all students in civil engineering, requirements in sanitary engineering undergraduate options, and a summary of requirements for the Master's degree with a major in sanitary engineering.

Second, the *1956 Report* gives the number of engineers and sanitarians receiving graduate training in accredited schools of public health in North America during the years 1954–55, 1955–56, and an estimate for 1956–57. Information, tabulated by states, is also given for the number of sanitation personnel receiving educational leaves for graduate training.

COLLEGE NOTES

NEW PROGRAM AT CONNECTICUT

The Electrical Engineering Department of the University of Connecticut has established a doctoral program in the field of "Network Theory and Feedback Control Systems." A similar program leading to the M.S. degree has been operating since 1950. Both the curriculum and research activities have now expanded to the point where it is now appropriate to offer doctoral level work as well.

The present Electrical Engineering graduate curriculum involves 28 regular courses pertaining to specific problems which are offered as interest warrants. The advisory committee for this program consists of Professors V. B. Haas, R. J. Kochenburger, and H. M. Lucal. In addition, other members of the faculty will participate.

ENGINEERING COLLEGES RESEARCH CAPABILITIES SURVEY

The National Science Foundation has granted $40,000 to the Engineering College Research Council of the ASEE to support a survey of the capacity of American engineering colleges to do research in the engineering sciences. The project will be administered by a special ECRC Advisory Committee consisting of Chairman Eric A. Walker. The Pennsylvania State University; Clark A. Dunn, Oklahoma A. & M. College; Ralph A. Morgen, Purdue University; Harold K. Work, New York University; and Raymond J. Woodrow, Princeton University. Robert H. Ramsey, The Pennsylvania State University, has been designated Survey Director.

Personal visits will be made to each of the 109 accredited engineering schools in the country to obtain the survey information, and interviewers designated by members of the Committee from their respective schools will make the visits during the summer of 1957. The interviewer teams, armed with questionnaires, will discuss the survey requirements with responsibile school research administrators. Results of the survey will be presented to the National Science Foundation in a final report by December, 1957.

A summary report which includes research capabilities of individuals from each school, and needs for equipment, facilities, and money can serve to clarify often misunderstood conditions that exist in engineering research areas today. The report also will list engineering research capabilities, provide estimates on the amounts of time that trained individuals might devote to research problems if funds were made available and estimate, the funds that should be appropriated for engineering research.

CORNELL POINTS OF INTEREST

While attending the Annual Meeting at Cornell University in June, ASEE members are invited to visit the Airphoto Center, which coordinates aerial photography training and research for the whole university. The center, located in Lincoln Hall, gives students from all divisions—such as engineering, geology, city and regional planning, and agriculture—basic training in photogrammetry and photo-analysis.

It also has three-week short courses for engineers and geologists from oil, mining, and consulting firms, and from government highway departments. A Rangoon branch of the center has trained personnel for the Burmese government.

Research projects have reached base camps in the Arctic, in Burmese jungles and on African and Philippine beaches. Objectives range through population studies, geologic mapping, military geology, land classification, and archeology. Several studies are being carried on in analytical aerial triangulation using a high-speed electronic computer.

The structural testing laboratory in Cornell's Thurston Hall is another point of interest for ASEE visitors. The main wing, measuring 55 by 60 by 40 feet high, can handle tests on full-scale bridge and airplane components. Heavy laced columns that support the roof are designed for a vertical downward load of 750 kips at any point, a vertical upward load of 50, and a horizontal load of 50. The upward load can be increased to 250 kips by tying the columns to nearby anchors that reach to bedrock. The floor can withstand a load of 100,000 psf, and its center, concrete down to bedrock, can take almost any load.

Current projects are tests of light-gage steel structures under conditions simulating wind and earthquake; other tests include those for light-gage steel structures with bolted connections, to find the effects of various plate thicknesses and bolt arrangements; and an experimental study of a full-scale pressure vessel.

65th ANNUAL MEETING
CORNELL UNIVERSITY
ITHACA, NEW YORK
JUNE 17-21, 1957